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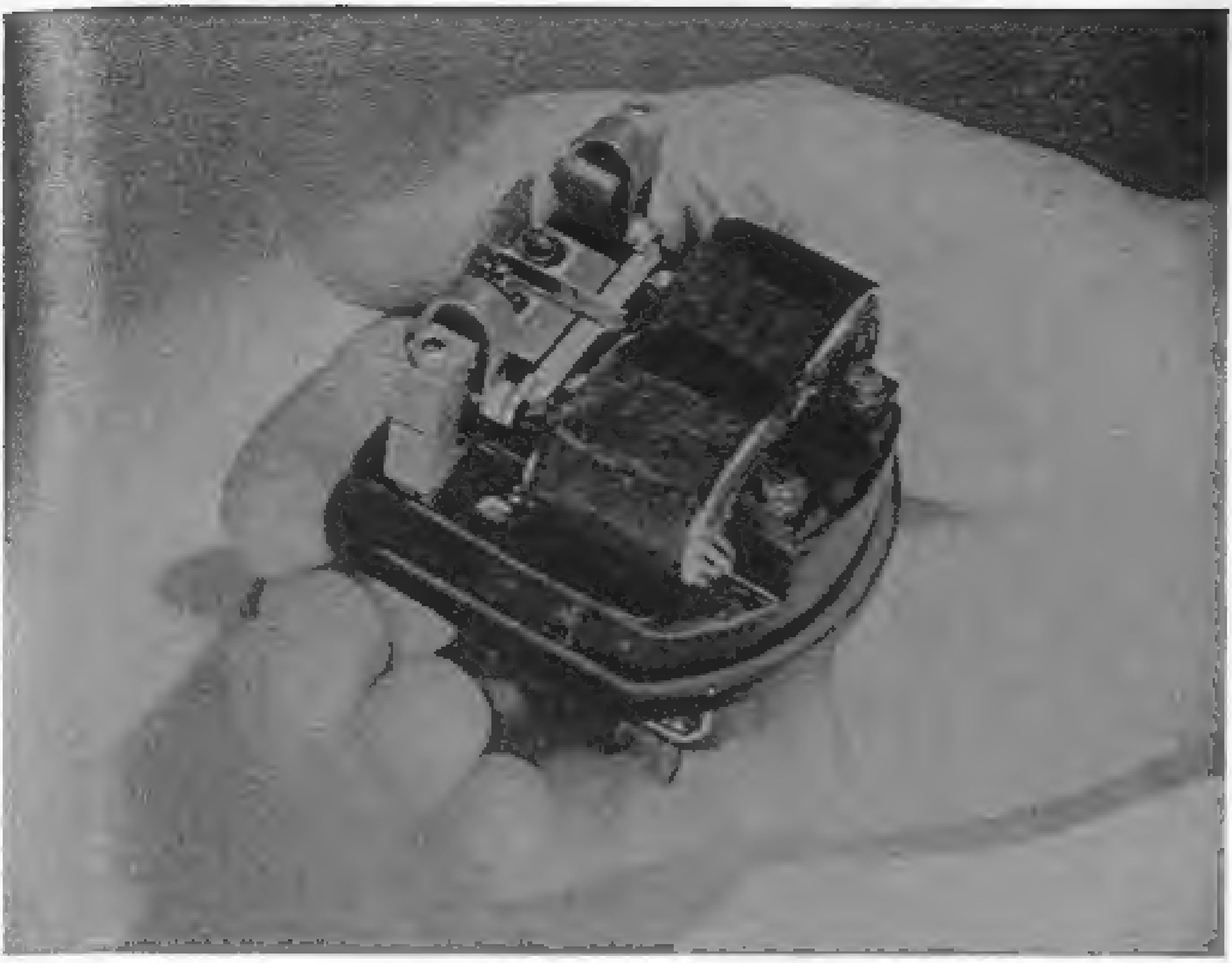


T. FRANK CASSIDY, JR., Manager, Subscriber's Station Apparatus,
Automatic Electric Company

Manufacture of Western Union Type 202 Polar Relay

In the January 1952 issue of the Western Union Technical Review, an article by W. D. Cannon and T. Rystedt titled "An Improved Polar Telegraph Relay" described a new relay designed and developed by Western Union engineers which was then at the prototype model stage. This article gave a full technical description of the relay, its construction, characteristics, and design objectives that would provide for improved performance, dependability and long maintenance-free operation, together with low cost manufacture.

The many thousands of these relays that have been placed in service during the past four years show that these objectives were well met. Reports of relays with over a billion operations between readjustment are not unusual.

In October 1952, Automatic Electric Company arranged with the Western Union Telegraph Company to tool up and produce this new design. Designated the Type 202 Polar Relay, the device that went into production was, generally speaking, the one described in the Cannon and Rystedt article. A major im-

provement, however, was in the method of securing the armature reed by silver brazing, as illustrated. The primary subject in this paper, however, is the manufacturing processes employed, including quality control procedures.

the relay will remain stable over a long period of time. The cover is molded from a powder with a rubber filler. This gives resiliency and acts as a noise deadener to prevent transmission of the buzzing sound from the relay contacts. The plug portion

Telegraph apparatus employed in Western Union operations usually is designed in the company's own research, development and engineering laboratories but is manufactured, as a rule, by established electrical equipment suppliers. Polar relay type 202, which is replacing type 17-B and other older relays by the thousands, is just such an item.

Quality control procedures are important from procurement of materials through fabrication processes to final inspection. While soundness of design is, of course, a primary requirement, production of a superior telegraph component such as the 202 relay is the result of coordinated effort by everyone concerned from machine operator and assembler to the manufacturing and design engineers. Techniques of production of this relay which are more or less typical of those involved in manufacture of the telegraph company's modern communications equipment make an interesting and informative story.

In the design of the Type 202, every precaution was taken to make the parts simple and to eliminate adjustments wherever possible, particularly those having to do with routine maintenance. It might seem at first that this would permit relaxation of tolerances and simplification of tooling and manufacturing procedures. Just the contrary is true, however. Parts that cannot be adjusted must be designed and built to such tolerances that any part falling within those tolerances will properly perform the desired function. The attainment of this objective requires close coordination between design engineering and manufacturing engineering, together with all phases of material specification, manufacturing processes, tooling and quality control. This close coordination was readily achieved in the case of the Type 202, and satisfactory relays were being produced six months after the start of the project.

Superior Materials Used

One of the basic steps in turning out a quality product is careful specification of the materials and commercial parts that go into the product. For example, the three molded parts of this polar relay are produced from different molding powders. The base, which is the structural backbone of the relay, is made from a mineral-filled powder. This imparts high dimensional stability to assure that the adjustment of

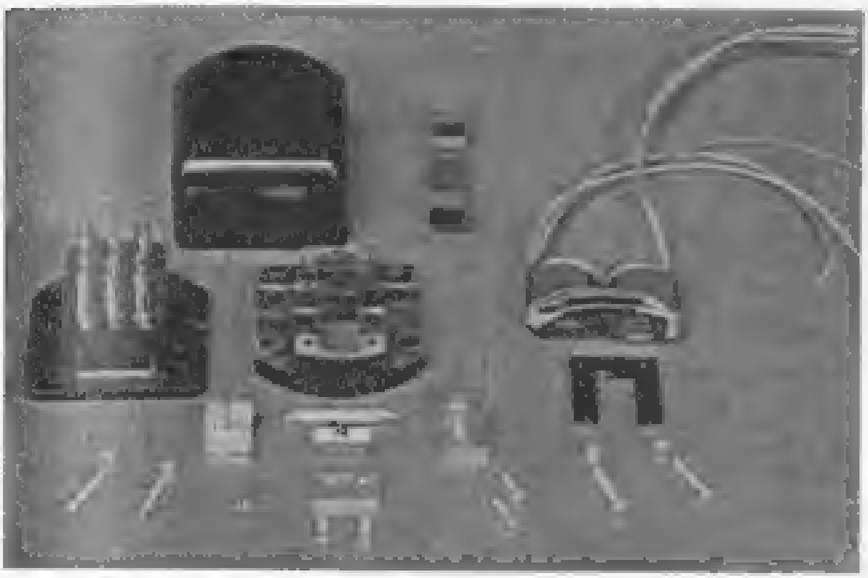
of the base, which carries the banana pins, is molded from a compound having both wood-flour and mineral filler which gives strength as well as resiliency.

The laminations of the core assembly are made from a low-core-loss silicon iron to reduce loss of electrical energy in the core, and to maintain the over-all efficiency of the relay. Likewise, the armature bar is made from a nickel-iron alloy which has higher permeability than ordinary magnetic iron. The armature reed is blanked from an 18-8 stainless steel strip of controlled hardness, since the stiffness of this member has a direct effect on the operating characteristics of the relay. The tungsten carbide chosen for the contacts is a formulation which assures the desired characteristic hardness and wear resistance available in tungsten carbide. This also provides resistance to metal transfer under arcing conditions, and sufficient toughness or impact strength to resist fracture under high operating speeds.

The copper wire used in the coils is a "Formex" wire insulated with a coating of polyvinyl acetal. This gives superior insulation and heat resistance, toughness and resistance to abrasion. The insulating tape used to separate the windings in the coil furnishes excellent insulation resistance not only for the high temperatures encountered in continuous relay operation, but for high humidity conditions as well.

Quality Control

Proper specification of purchased materials and parts must then be followed by careful inspection of incoming materials, supplemented by laboratory tests where indicated. It is Automatic Electric Company practice to specify raw material requirements by description and specification number on the piece part print. These are prepared by Automatic Electric engineers and, in general, follow S.A.E. or A.S.T.M. specifications, but may be more exacting or detailed in certain respects. The scope of the tests to be run on any given lot of material is covered by standing inspection procedures issued by the quality control department. These procedures apply the principles of statistical quality control. Wherever a material or part is of a critical nature, a special inspection procedure is written to insure that the desired qualifications will be met. The quality control department has at its disposal a well-equipped laboratory with facilities for making all needed chemical or physical tests.



Functional components of Type 202-A relay

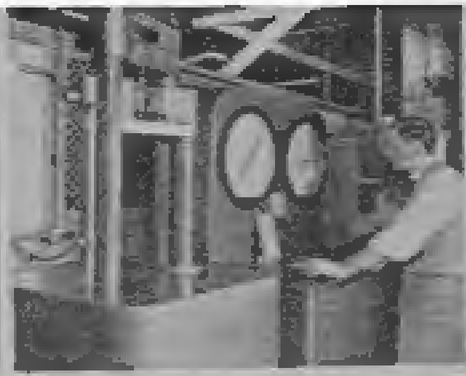
The manufacture of this Type 202 Polar Relay involves a wide variety of fabricating techniques and processes. Sheet metal parts such as the coil laminations, contact springs, armature reed and reed support are perforated and blanked in high-speed punch presses from strip stock. Secondary forming operations are accomplished in presses where the operator places a blank in the nest of a die from which it is automatically air-ejected after forming.

Several of the parts, such as the pole piece, the armature bar and the contact supports are not suited to punch-press operations because of the thickness of the material or the finish desired. These parts are therefore machined by milling. By careful selection of cutter speeds and feeds, correct finishes are obtained with essential dimensions held to close tolerances. Holes required in these parts are drilled rather than perforated and the tapping is done in air-operated tapping machines.

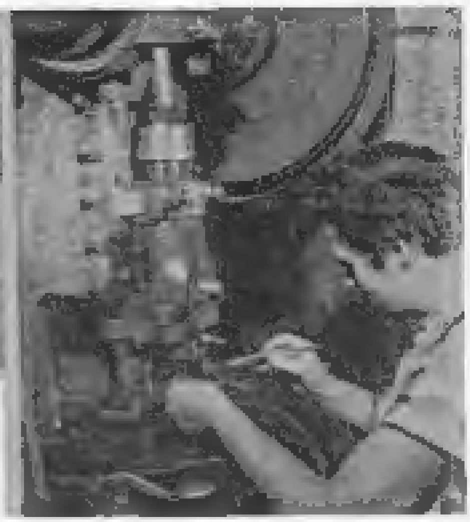
Grinding or sanding is used on several parts either because of the hardness of the material to be removed or the type of surface desired. For example, the lamination assembly is made by riveting together nine laminations and subsequently furnace-annealing the complete assembly. Since the resulting surface adjacent to the armature bar may be somewhat rough, grinding is used to eliminate slight irregularities and produce a smooth surface without burrs. After the contacts are brazed to the armature bar, the tungsten carbide contacts of the armature assembly are ground to the desired dimension and finish.

The molded relay base and subbase are sanded to remove flash, and to produce a perfectly flat surface that will eliminate any distortion in assembly. The molded parts of the relay are made from thermosetting phenolics either directly from powders in compression molds or from preformed "biscuits" in transfer molds. In compression molding, the powder is heated and compressed in the mold cavity itself, whereas in transfer molding a preheated biscuit is brought to a plastic condition in a separate chamber and is then forced into the mold cavity. In either case curing is accomplished by a combination

Wiring and soldering leads to banana pins



Tension testing screws to destruction



Secondary operation press forming brackets

of temperature, time and pressure so that these three variables are accurately controlled.

The relay coils have four independent windings each and, because of the limited space available, the wall thickness of the spool frames must be kept to a minimum. The spool heads of the spool frame are perforated and blanked from sheet fibre and the core is made from spiral wound fibre tubing. The heads are locked to the tube by a mechanical crimp and then are cemented in place. The coil windings are applied individually and are insulated from each other with a temperature resistant tape. The lead-out wires are brought out along the edge of the spool head and are also insulated with tape. After the last winding is applied, each of the eight lead-out wires is spliced to a plastic insulated connecting wire, and each splice is individually tape-insulated before application of the final hold-down tape and coil cover.

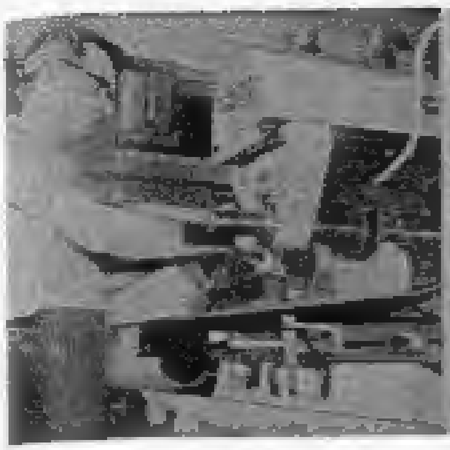
Inspection of the coils includes tests for resistance, short-circuited turns, and a 1000-volt breakdown test between windings. When the coils are slipped onto the laminated core they are also tested for breakdown to the core.

Brazing Contacts and Armature Parts

Copper brazing in a hydrogen atmosphere furnace is used in the fabrication of the contact assemblies. The armature bar is placed in a fixture which properly positions the tombstone-shaped, sintered tungsten carbide contacts in the notches milled in the ends of the bar. A thin sheet of copper between the contact and the bar melts at a temperature in excess of 2000 degrees. A slight reducing atmosphere is maintained so that oxides do not form and the molten copper adheres readily to the parts to be brazed. Incidental to this process, the nickel iron bar is thoroughly annealed to bring out its optimum magnetic properties. In a similar manner the round mating contacts are copper brazed to a stainless steel backing having welding projections on the outside. After brazing, this assembly is projection-welded to the stainless steel support spring. In this operation, heat must be kept to a minimum to prevent annealing or the spring will lose its temper.

All screws are case hardened to prevent burring of the heads. This is done by immersing them for a predetermined period in a molten bath of cyanide and then quenching in water.

Parts which are not inherently corrosion resistant are either electroplated or parkerized by conventional means. Limiting thicknesses of plating are specified in milligrams per square inch, and quality control checks involve accurate weighing of parts after plating and then after stripping off all plating. The difference in milligrams is divided by the total number of



Gang milling contact support block

Racking lamination assemblies for annealing

Removing relay base from bakelite mold

square inches of computed surface area of the part.

The banana-pin assemblies used to extend connections to the mating socket are fitted together by placing two press-formed stainless steel springs over a projection on the end of the turned stud and riveting over this projection. The dimensions of these springs are carefully controlled to insure proper contact pressure with the mating socket.

Silver brazing is used to fasten the armature reed to the armature bar. The parts are supported in a jig and the juncture of the two parts is heated with an acetylene torch. Flux and silver solder in wire form are hand fed by the operator. In a like manner, the opposite end of the reed is brazed to the armature support bracket in a jig which locates the armature bar in relation to the supporting surface of the bracket.

In the fabricating departments each new setup requires the approval of quality control inspection before the job can be run. Floor inspectors spot-check jobs in progress and shut down any operation that is not up to standard. When a given job lot is completed and ready for transfer to stock or to another department, it must be checked and approved by the inspector before it can be moved.

The final assembly of the relay starts with the several subassemblies. The banana pins, washers and nuts are assembled to the molded plug in a holding fixture which supports the banana pins while the nuts are run down with an electric driver set to a predetermined torque. The coils are fixed in pairs to the legs of the lamination assemblies and splices are made between coil leads.

The Alnico III cast magnet, which is stocked in an uncharged condition, is fully magnetized and a flux reading is taken. Since this reading is always considerably higher than that desired for optimum operation, the magnet is then partially demagnetized on an alternating-current electromagnet with variable voltage supply. By varying the time and the input voltage a skilled operator readily demagnetizes the magnet until it falls within the desired flux range.

Final Assembly

The first step in the final assembly of the relay is mounting the pole piece and contact spring supports to the molded relay base. A layer of cement is applied to these parts before assembly to insure that they will remain in place after assembly of the relay and thereby prevent change in adjustment. The assembly fixture insures proper alignment of the parts in relation to the molded base and to each other. At this point the permanent magnet is placed in position, after first insuring that the ground surfaces make proper contact with both the core assembly and the pole pieces.

The next subassembly to be added is the lamination assembly carrying the two coils. The gap between the lamination assemblies and the pole piece is critical,

Winding and insulating [illegible]

Silver brazing armature assembly

Testing and adjusting completed relay

and this gap is set to a gauge in a special fixture before the core assembly screws are tightened. The operator checks the gap setting with a "go" and "no go" gauge after tightening the screws. The contact spring assemblies are now attached to the contact block, and the adjusting and locking screws are inserted.

The next operation is the wiring and soldering of the plug subassembly to the coil leads and contact supports. When this wiring has been completed and inspected the two parts of the relay are screwed together. Lockwashers are used to prevent loosening of fastenings wherever they can be applied, and elsewhere a Glyptal cement is used.

The armature subassembly is attached to the pole piece without completely tightening the screws. The relay is checked out by an inspector at this point and passes on to an adjuster.

Adjustment and Testing

The adjuster first positions the armature bar in relation to the core assembly using nonmagnetic feeler gauges. The armature support bracket is then carefully screwed down without applying any bias to the armature reed. The two adjustable contacts are brought up to proper position in relation to the armature bar. Special paper gauges are used between the contacts so as not to leave any metal residue on the tungsten carbide, and the relay is now ready for electrical test and final adjustment.

The next adjuster follows a test procedure set up by the quality control department for use with the special equipment designed and constructed for this purpose. The relay is tested and adjusted where necessary to insure that it centers properly and has the desired banking force on each side. It must show at least 80-percent efficiency when operated with a 60-cycle sine wave input. This is determined by measuring the ratio of the time the contacts are in motion, to the time that they are on contact. These tests are run for each of the four sets of windings and in each case specified minimum limits —limits which are more rigid than those at the inspection position—must be met.

The adjuster now puts a cover on the relay to prevent any change in adjustment due to handling, and to keep out dirt.

After adjusting is complete all permanent fastenings are locked in place with Glyptal cement and a manufacturer's decal is applied.

The final inspector, who performs the same tests as the adjuster, applies a 1000-volt breakdown test between all electrical circuits, checks all gauging and gives the relay a complete visual inspection. It is then stamped by the inspector to show that it is complete and ready for customer inspection and shipping.

In this article emphasis has been placed

on the many inspections required to insure that high quality standards have been maintained at all steps of manufacture. It goes without saying, however, that no amount of inspection builds quality into a product. Quality is the result of a coordinated effort by everyone concerned from the machine operator and assembler up to the design and manufacturing engineers and production supervisors, and is best summed up as "manufacturing know-how."

T. Frank Cassidy, Jr., manager, Subscriber's Station Apparatus, Automatic Electric Company, was born in Connecticut and received an M. E. degree from Rensselaer Polytechnic Institute in 1928. He was employed by the Gray Telephone Paystation Company (later the Gray Manufacturing Company) until 1948 when he transferred to Automatic Electric Company when that company bought the telephone paystation business. While with the Gray company, Mr. Cassidy held positions in the engineering, quality control, production and sales organizations, and as plant manager put into production numerous items including switchboards and other communication devices for the Army Signal Corps and air-borne radar equipment for the U. S. Air Force and the U. S. Navy. He is a member of the ASME and past chairman of the Hartford section.

More Telegraph Automation for U.A.L.

A new telegraph switching center, one of six on a 30,000-mile private wire network which United Air Lines leases from Western Union, is in operation at United's new $6 million terminal at Idlewild Airport, New York. Similar installations at Chicago, Denver, Seattle, San Francisco and Los Angeles serve the U.A.L. 80-city system to make possible minute-to-minute reports on the status of all 270 daily Mainliner flights.

The New York center employs a master-message transmission device, enabling an operator to contact all stations or any combination of stations merely by pressing buttons. United Air Lines' private wire network is one of the largest and most modern in commercial use. It carries more than 3,000,000 messages monthly, with daily traffic estimated at 2,500,000 words, for 250 United offices coast to coast.

BERNARD L. KLINE, Assistant to Physical and Chemical Engineer

Corrosion, A Versatile Vandal

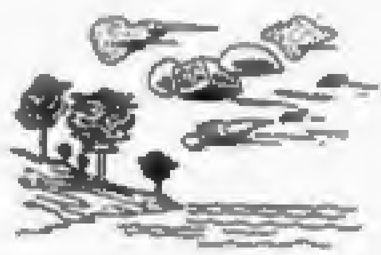
CORROSION probably suggests green encrusted copper line wire, rusted bolts, blistered paint, and other obvious evidence that all are accustomed to seeing, mainly in outside plant installations. The forces of corrosion are impartial, and industrial organizations which are not troubled by corrosion problems directly or indirectly are truly exceptional. The outside plant naturally accounts for the major portion, with its vast network of wire and cable, both aerial and underground, and the necessary accessory equipment and hardware. Much of this is a familiar sight to those who have used glass insulators as targets, or who have travelled by train, noting, with rhythmically undulating optics, the spans of green wire supported by the rows of poles.

This corrosion, however, is not news any more than the brown or green stains in the kitchen sink, or the rusty chrome plate on automobiles, and the basic theories, diagnoses, treatments, and preventative measures are fairly well known. All these are deliberately omitted from this discussion in favor of some of the special cases and circumstances which so often require that theories be revised to fit the facts. When these special problems are brought to the laboratory the investigation is anything but routine, since the request for chemical examination usually includes not only what might be called diagnostic analysis, but identification of the person or persons responsible, and hypothesis as to what aberration existed in his mind to impell him to commit such a blunder anyway. There is absolutely no intention here to be recriminative, and personalities and locations are omitted. These things can happen anywhere and to anyone and the whole point of this is to warn against reaching for an easy or hasty conclusion.

Illustrations by James J. Benson, Senior Engineering Assistant, Physical and Chemical Division.

Beware of Chlorides

There have been many cases of corrosion of complicated equipment shortly after assembling or after routine cleaning and oiling, and analysis has shown many of these to be due to chlorides. Now it is unwise to assume that the corrosion of the equipment referred to took place on a beach with a brisk on-shore breeze, although it is surprising how far air currents will carry tiny salt crystals inland from the ocean.

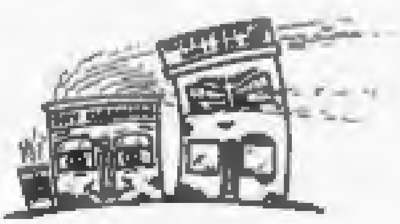


Chlorinated hydrocarbons such as carbon tetrachloride are commonly used, however, for cleaning equipment and parts. The proper solvents must be selected for specific cleaning problems because under special circumstances and in presence of damp air some of these solvents are subject to very slight decomposition with formation of traces of hydrochloric acid, whose corrosiveness is unquestioned. The cleaning operation will give all indications of having been successful until a few days later when a bearing or pivot will freeze due to corrosion. This is particularly common when equipment has been cleaned in muggy summer weather and not thoroughly and promptly dried. In this case the bearing holds the solvent almost like a bottle with a loose-fitting stopper and moist air has time to

work on the solvent to form acid. Also leaving such solvents in open pans or trays in contact with moist air is likely to cause the solvent to become corrosive.

Carbon tetrachloride is one of the more susceptible solvents to this kind of action and although it has rather generally been replaced by other much more stable relatives, it is still used occasionally and without regard to the necessity for prompt evaporation of any excess. Many small fire extinguishers which are loaded with carbon tetrachloride have become obstructed by corrosion in the delivery nozzle and the tube due to failure to shake out the liquid from this tube after testing and refilling. In a very dry location this is not so important, but in damp spots trouble is to be expected.

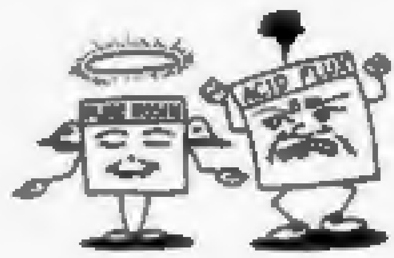
Here is a case that happened only once in our experience. The equipment in a small telegraph office had been behaving quite normally for some time and then showed noticeable corrosion that developed within a few weeks. It was chlorides all right, but no soldering (with corrosive flux) or cleaning had been done. Furthermore, other metals and hardware also were affected. It was only after the search was extended that it was learned that the dry-cleaning and pressing establishment next door had recently discontinued conventional cleaners' naptha in favor of carbon tetrachloride! It should be repeated that for most cleaning operations



other more stable chlorinated hydrocarbons such as trichlorethane are in general use and are substantially free from this corrosive tendency.

Solder Flux Can Cause Trouble

There are also frequent cases of corrosion adjacent to soldered joints and here, although it is again due to chlorides, the offender is the soldering flux. It is surprising how often a No. 30 wire will corrode through and break because, even though the solderer had obeyed instructions implicitly and used no flux other than pure rosin, the iron had just previously been used with another flux by someone else. Even when there is no failure of the wires, many elaborately wired devices have lost electrical balance and become useless when exposed to a day of high humidity which caused the residual solder flux (not rosin) to become conductive.



Of course, it is not always chlorides that are responsible for corrosion of telegraph equipment and there are times when materials must be replaced by other compositions when some corrosive condition must be accepted. In a tobacco-curing warehouse, for example, tarnish of electrical signalling equipment was found to be due to alkaline atmosphere and the usual materials that withstand the more normal slightly acid conditions did not adequately resist alkaline attack.

In a meat-packing plant equipped with telegraphic alarm circuits, certain special watchmen's key die castings corroded while other similar ones did not. A difference in the metal alloys was found which caused some of them to be affected by the fats which were of course distributed throughout the plant, a situation which required that a specification for die castings be revised to outlaw the susceptible alloys.

When a report was made that someone had spilled black paint that dripped on a wall-mounted switch panel the cure was to move the panel because the "paint" turned out to be a highly acid sooty condensate from a furnace chimney which had developed a crack near the base.

Obvious Suspect Not Real Offender

There have been instances of corrosion where the explanation borders on being fantastic, but they were nevertheless very real, indeed. A piece of corroded lead-sheathed underground cable was sent in for analysis from a West Coast point. The encrusted corrosion products were chlorides, but when the chemist's report suggested that sea water may have been responsible the reply was made that this could not be possible because the cable ran through a cinder bed under a railway siding, hundreds of feet above sea level, and served a textile manufacturing company's plant and offices. Obviously, then, it seemed corrosion should have been due to sulphates from the cinders rather than chlorides and the salt water analysis was viewed with considerable scepticism until it was learned that the previous tenant of the building was an ice cream manufacturer who had used great quantities of salt and brine which impregnated the ground area.

Now here is another situation that could happen again, and perhaps even frequently. A pneumatic tube installation connecting a Western Union telegraph office with an adjacent bank building had given no trouble for some years, but suddenly failed in the middle of a spell of hot, humid weather. When the tube line was taken out it was found that a curved section of the tube was made of steel and had rusted so badly that the carriers were jammed.

A chemical analysis was made and it was a bit startling to find absolutely nothing of an unusual chemical nature that could explain the corrosion—just plain rust. Since this kind of answer is not accepted in the telegraph company's chemical laboratory further investigation was done. The answer was extremely simple. The offender was distilled water. The bank had just installed a new and highly efficient air-conditioning system and as the hot, moist air in the tube reached the cool section in the bank, precipitation occurred which had very little effect on the copper tubes but plenty on the steel section.

"The Case of the Falling Ceiling"

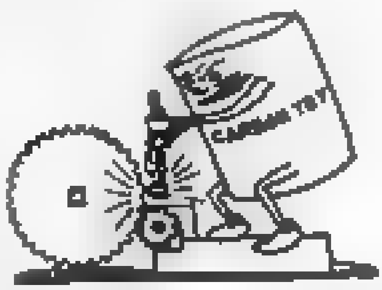
Another example of unexpected corrosion occurred in a small building constructed for use as a Western Union office in a city near the ocean. This building was constructed of reinforced concrete and everyone was very happy about it for some years. Hairline cracks then developed in the ceilings and became progressively worse. Finally, pieces of concrete loosened and occasionally fell constituting not only a nuisance but a hazard since the concrete pieces were obviously breaking away from the steel reinforcing rods which were very badly rusted and blistered.

This called for chemical examination and it was established that the builder had taken a short cut and used sand from a nearby salt-water beach instead of proper building sand and the combination of salt and constant humidity caused disintegration of the steel rods. The cure for this was strictly mechanical, not chemical.

An interesting case of blistered paint occurred in the case of some isolated power stations where metal fireproof doors were installed at the entrance to the small furnace rooms that housed oil-burners. When the paint on the doors started to blister it certainly appeared that the difficulty arose from an acid condition either from the oil fumes or from the cinder block of which the walls were constructed.

Chemical tests showed sulfates and an acid condition at the blisters but two peculiarities were noted. Other painted metal parts nearby were not blistered and when the blistered paint from the doors was carefully scraped off the metal was clean, free from rust, and showed one or more tiny pinholes near the center of the blistered area. A panel was removed from the door and then it was apparent that

the door was corroding from the inside through to the outside. The answer was that the airspace within the doors had been filled with a blast furnace slag which was acidic, and with the help of atmospheric moisture was simply eating its way through the metal.



Almost always an explanation can be found for corrosion no matter how fantastic it may appear at first but one case will forever remain a mystery. A metal conduit was installed carrying a circuit into a silk textile mill, and gave no trouble for several years. Then a failure which occurred in the circuit was traced to a point in the conduit underground several feet from where it entered the mill. A badly corroded and eaten-through section was uncovered, cut out, and sent in for examination. On either side of the corroded area the conduit was in good condition, showing a very local deterioration. Chemical tests established a very strong acid condition but no chlorides, sulfates, acetates or other common corrosive materials were present. Instead, the culprit proved to be nitric acid but how it got there will never be known.

Trouble is Not Always Present

Now as a warning against premature assumptions, here are a few examples of a more special nature.

In a tunnel, some lead sheathed cables acquired a heavy grey-white encrustation which is the usual appearance of the most common form of lead corrosion. Fortunately the encrustation was thick and an adequate sample of it could be taken without disturbing the cable. A surprising analytical finding was an absence of lead compounds. The deposit had developed from ground water containing calcium salts that had dripped onto the cable and evaporated. Usually this causes corrosion of the lead sheath but in this instance it was fortunate that owing to favorable chemical conditions the cable was not affected.

Several years ago a special and very complicated wiring installation was made and mounted on panels that were no closer than 18 inches to the floor. After only a few months of operation, which included hot summer weather, circuit trouble developed and greenish-white deposits appeared on terminal lugs and ends of insulation. Chemical tests were made immediately and it was found that, first, there was practically no corrosion of lugs, solder, or conductors, and second, the deposits were sodium carbonate, a common ingredient of scouring powder. In addition there were found small particles of specific abrasive materials which are usual in scouring powders.

The question as to how scouring powder got into the panels was not answered at once but, having positive identification, on investigation it was learned that after the cable forms had been assembled they were placed temporarily on the floor in a room that was serviced by an over-enthusiastic porter who sprinkled scouring powder about and then attacked it with a wet mop. The water splashed the powder on the forms and the sodium carbonate, being readily soluble, soaked into the ends of the insulation. On drying there was no evidence of any deleterious effect, but after repeated cycles of absorption of water from the humid air and drying out, the sodium carbonate concentrated on the bare wire at the soldered terminals and finally accumulated to such an extent as to cause electrical leakage between terminals. Thus "corrosion prob-

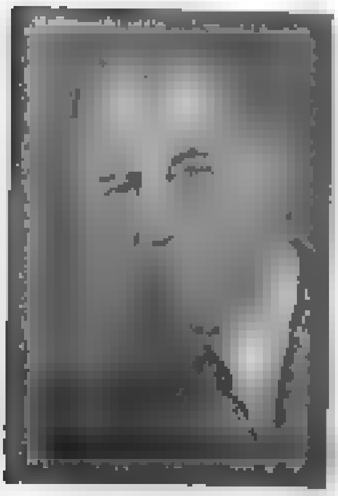
lem" was remediable by brushing off the deposits and spraying the cleaned areas with a water-proof lacquer to prevent further moisture from entering.

Now for the final example which fortunately happened only once.

A section of lead-sheathed cable in a manhole was observed to have unusual corrosion deposits developing. There were the common greyish-white areas, and dark grey, and brown, all of which aroused no particular alarm, but in addition there was a small area that was definitely red. In order to investigate this strange condition a short section of cable was cut out, a new section inserted, the corroded piece was carefully packed in a wooden carton protected with excelsior and cotton so as not to disturb the deposits, and was sent in to the Western Union laboratory for analysis.

The red area was found to be a lead oxide as expected, but in addition to lead oxide there was found dried linseed oil and no corrosion of the sheath underneath the spot. Who spilled the red lead paint on the cable still is a mystery.

The moral of this story is that the unexpected or unobvious not only can but *does* occur, and a sound chemical examination often plays a reliable and revealing part in an investigation. It is said with some merit that we should believe nothing we hear and only half of what we see.



Bernard L. Kline received his degree of Chemical Engineer from Brooklyn Polytechnic Institute in 1925 and was associated with Charles Hellmuth and Company, printing ink manufacturers, for a year before joining the Western Union Engineering Department in 1926. He is Assistant to the Physical and Chemical Engineer and is the company's head chemist. Besides extensive work on inks, Mr. Kline has been very active in the development of electrochemically sensitive coatings for facsimile recording papers and has had over 25 patents issued in this field. Researches on lacquer, resins, wood preservation, rust proofing, corrosion, wax compositions and detergents are included in his Western Union activities. Mr. Kline is a member of the American Chemical Society.

Fernand Emile d'Humy

1873 - 1955

It is with profound regret that the Western Union TECHNICAL REVIEW records the passing of Fernand E. d'Humy whose foresight, inspired leadership and able direction in telegraph research and engineering led to so much of Western Union's technical progress, including establishment of this publication.

It is difficult to tell briefly the story of a lifetime of accomplishment but these words from the published proceedings of The Newcomen Society of England, American Branch, are most significant:

"Internationally known and internationally respected, a pioneer in every sense of the word, and possessed of extraordinary vision based upon a lifetime of experience, Mr. d'Humy combines scientific and technical skill of a highest order with a rare sense of spiritual understanding.

"Born in London, he came to this country as a youth in 1888. He already had received private tuition in England, under the noted scientist Sir William Varley, and in this country he pursued his technical education which finally led to the Massachusetts Institute of Technology.

"The written-message communications art will forever be indebted to Mr. d'Humy for his exhaustive research and development work in connection with three very important features that will figure conspicuously in the Telegraph of the future. These are: the short-wave radio beam in lieu of poles and wires, the semi-automatic reperforating of telegrams in lieu of manual operation, and perhaps greater than either, the telefax—a device for the transmission of intelligence in picture form.

"It has not been our good fortune merely to have Fernand d'Humy the *Engineer* — it has been our greater fortune to have Fernand d'Humy the *Man*. We in the telegraph business who have been closely associated with him over the years are gainers from that association. In his generosity and warm understanding, in his sympathetic approach to the many problems he has had to face—we have found inspiration."

An award to be known as the F. E. d'Humy Medal has been established by The Western Union Telegraph Company in recognition and commemoration of the outstanding achievements of the late Mr. d'Humy. The medal, with an appropriate certificate and an honorarium of $500, will go to a Western Union engineering, research, scientific or technical worker who has made a most significant contribution to the telegraph art.

W. DALE CANNON, Assistant to Radio-Wire Transmission Engineer

Delay Distortion Correction

Imperfections in transmission circuit facilities cause signal distortion in which the pulse envelopes may be broadened, displaced from true positions or destroyed.

The transmission attribute sought is a uniform amplitude and delay response which is flat within prescribed limits over the essential bandwidth. Since delay cannot be subtracted from a given circuit the problem is to increase delay in all sectors to approximate the highest significant delay value. Compensation of distortion with active and passive networks is described, with the former the delay characteristic can be varied over a wide range and, with some types, amplitude characteristics also may be varied.

The author discusses amplitude and envelope delay distortion variations with respect to signalling frequency, and the development of a practical means of correction with specific reference to the envelope delay measuring instrument described in Western Union *Technical Review*, Vol. 10, No. 1, of January 1956.

IN FACSIMILE and data transmission systems the signals are largely transient in nature and are usually in the form of a modulated wave for transmission purposes. The modulating signals may be in the form of isolated pulses, periodic waves or various other waveshapes depending upon the nature of the communication device or system. Modulated pulse envelopes are thus present in the transmission medium in various combinations of amplitude, duration, and relative positions. It is therefore necessary to consider the transient response characteristics of transmission systems and associated networks as well as their steady-state properties.

A fundamental problem in the transmission of modulated pulses is the resulting distortion arising from imperfections in the transmission medium and circuitry in the form of amplitude and delay variations with respect to frequency and bandwidth limitations. In transmission the pulse envelopes may be broadened, displaced from their true positions or destroyed beyond recognition. Amplitude distortion usually can be corrected by simple means. Delay distortion correction, however, involves relatively more complicated measuring techniques and compensating networks.

It is usual to provide correction for envelope delay distortion and ignore other forms of delay distortion. An instrument has been developed for the measurement of envelope delay characteristics as well as amplitude characteristics.[1] By the use of this instrument these characteristics may be displayed continuously by a cathode ray oscilloscope. Thus each alteration in the characteristic by the insertion of corrective measures is immediately displayed so that the process of corrective insertion and observation is continued until the characteristic is within a prescribed tolerance. The usual passive recurrent-structure corrective network is unpractical for the rapid insertion of new delay values in small steps for observation. This paper includes consideration of distortion properties and the development of a more practical means of correction particularly for use in conjunction with the envelope delay measuring instrument.

Pulse Transmission Characteristics

Since facsimile and data signals contain waveshapes in the form of pulses and depend upon the relative phases of the component frequencies as well as upon relative amplitudes for preservation of waveshape, it is necessary to consider both amplitude and phase responses. It is usual to predict the transient response of a circuit or network from the steady-state amplitude and phase responses. These

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responses may be expressed in closed form by relations such as a Fourier Integral Equation

$$A(t) = \frac{1}{2} So + \frac{1}{\pi} \int_0^{\infty} \frac{S(\omega)}{\omega} \operatorname{Sin} [\omega t + \phi(\omega)] \, d\omega \quad (1)$$

where,

$A(t)$ response due to unit step function

So = response after the transient has disappeared

$S(\omega)$ = amplitude response as a function of ω

$\phi(\omega)$ = phase response as a function of ω

The phase response $\phi(\omega)$ can in general be expressed as the sum of three components. The first is the minimum phase component which has a definite relationship to the amplitude response and is therefore of particular interest with respect to limited bandwidths. In minimum phase systems equation (1) can be expressed in terms of either the amplitude response $S(\omega)$ or the phase response $\phi(\omega)$. The second is a linear component which represents a constant transmission time for all frequencies. The third component is independent of the amplitude response and hence may be used for application in networks for correcting the phase response to be a linear characteristic with respect to frequency. In this case $S(\omega)$ is a constant and transient response $A(t)$ is dependent upon the phase response $\phi(\omega)$. These components give rise to different forms of phase distortion. The properties of some of these forms will be considered briefly.

The amplitude response $S(\omega)$ and the phase response $\phi(\omega)$ are usually considered in terms of the steady-state parameters α, attenuation constant; and β, the phase shift constant so that the propagation constant is $\alpha + j\beta$. The phase related parameters that are associated with facsimile signal distortion may be expressed in terms β/ω which is the phase delay and $d\beta/d\omega$ which is the envelope or group delay. In addition, higher order derivatives are sometimes of importance particularly when aperiodic waves are involved.[2,3]

In the transmission of periodic waves or pulse trains such as are generated when a number of equally spaced lines are scanned, it is convenient to express such waves in the form of a Fourier series

$$E_{(t)} = \frac{a_0}{2} + a_1 \operatorname{Sin} pt + a_2 \operatorname{Sin} 2pt + ---- a_n \operatorname{Sin} npt + b_1 \operatorname{Cos} pt + b_2 \operatorname{Cos} 2pt + ---- b_n \operatorname{Cos} npt \quad (2)$$

where the parameters may be determined by the usual Fourier methods. If used to modulate a carrier, double sideband, the resulting transmission is

$$V_1 = A_1 \operatorname{Cos} \omega_a t \; [1 + ME(t)] \quad (3)$$

where

$\omega_a/2\pi$ = carrier frequency

A_1 = carrier amplitude

M = modulation factor

If this wave V_1 is transmitted through a medium having a linear phase shift as shown in Figure 1 curve 1, each sinusoidal component of $E(t)$ will be received in the form

$$V_2 = A \operatorname{Cos} \omega_a (t + k) + \frac{A b_n M}{2} \operatorname{Cos} (\omega_a + np)(t + k) + \frac{A b_n M}{2} \operatorname{Cos} (\omega_a - np)(t + k) \quad (4)$$

Hence, the carrier and two sideband frequencies will be delayed in transmission by the factor $\beta/\omega = d\beta/d\omega = k$ so that all components of $E(t)$ will be delayed equally and the waveshape will be preserved in transmission. If the medium has a linear phase shift which does not intercept the β-axis at 0 or $M\pi$, where M is an integer, as shown by curve 2 Figure 1, a form of distortion occurs known as linear phase intercept distortion. Here the phase delay $\beta/\omega = k + \beta_1/\omega$ and the envelope delay $d\beta/d\omega = k$ are not equal. In this

case each sinusoidal component of $E(t)$ will be received in the form

$$V_2 = A \cos[\omega_c(t+k)+\beta_1]$$

$$+ \frac{Ab_nM}{2}\cos[(\omega_c+np)(t+k)+\beta_1]$$

$$+ \frac{Ab_nM}{2}\cos[(\omega_c-np)(t+k)+\beta_1] \qquad (5)$$

which in envelope form is

$$V_2 = A \cos[\omega_c(t+k)$$

$$+ \beta_1][1 + Mb_n \cos np(t+k)] \qquad (6)$$

Hence, the carrier is delayed by the phase delay and the envelope is delayed by the envelope delay of the medium.

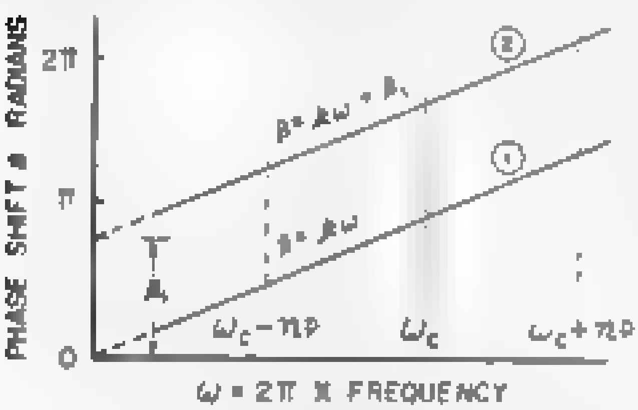

Figure 1. Linear phase shift characteristics

The question often arises as to whether linear phase intercept distortion is of importance in facsimile and data transmission systems where information may be present in the form of modulated pulses. whereas unmodulated signals such as the $E(t)$ waves of equation (1) when transmitted directly over a circuit could be distorted beyond recognition unless the intercept is 0 or $M\pi$. From the foregoing it can be seen that in the case of modulated signals the envelope is not distorted in transmission but that the carrier is shifted in phase under the envelope. Hence this form of distortion may be neglected, unless some use is to be made of the individual cycles of the carrier, in which case correction need be made only for envelope delay. However the peaks of the carrier cycles are often used for marking or sampling rather than the recovered envelope. In this case the necessity for intercept correction is minimized if the carrier frequency is high relative to the modulation frequency since the constant carrier phase shift angle β_1 will then represent a small time displacement relative to the signal interval. This relationship may be effected, if it should not naturally exist in the system, by frequency multiplication at the receiver which will multiply the carrier frequency ω_c and leave the modulation frequency unchanged.

For a medium in which the phase shift is not linear, a number of different types of distortion arise depending upon the phase characteristic. A few types of phase characteristics are discussed in the following. Since a delay common to all signal frequencies produces no waveform distortion, that part of the phase shift which is linear with frequency may be ignored for present purposes. The results of non-linear distortion may for convenience be expressed with respect to the average value of the phase shifts β_4 and β_6 of the side frequencies of a component of $E(t)$ Figure 2. The received modulated component then will be

$$V_2 = A \cos(\omega_c t + \beta_2)$$

$$+ \frac{Ab_nM}{2}\cos[(\omega_c+np)t+\beta_3]$$

$$+ \frac{Ab_nM}{2}\cos[(\omega_c-np)t-\beta_3] \qquad (7)$$

$$= A \cos\omega_c t\,[\cos\beta_2 + b_nM\cos(npt+\beta_3)]$$

$$- A \sin\omega_c t\,\sin\beta_2 \qquad (8)$$

where

$$\beta_2 = \frac{\beta_4-\beta_6}{2} \quad \text{and} \quad \beta_3 = \frac{\beta_6+\beta_4}{2} \qquad (9)$$

which in envelope form becomes

$$V_2 = A\sqrt{1 + 2b_nM\cos\beta_2\cos(npt+\beta_3) + b_n^2M^2\cos^2(npt+\beta_3)}\;\cos(\omega_c t + \theta) \qquad (10)$$

where

$$\theta = \tan^{-1} \frac{\sin \beta_3}{\cos \beta_2 + b_n M \cos(npt + \beta_3)} \tag{11}$$

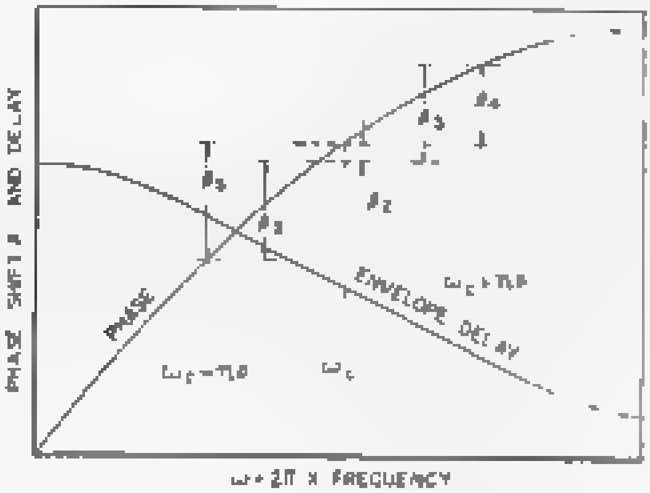

Figure 2. Nonlinear phase shift characteristics

It will be observed that there is envelope distortion due to the presence of the Cos β_2 term and some degree of phase modulation due to the variation of θ with npt. If the phase shift $\beta_2 = \pi/2$ the envelope of equation (10) becomes

$$A\sqrt{1 + b_n^2 M^2 \cos^2(npt + \beta_3)}$$

$$= A\left[1 + \frac{b_n^2 M^2}{2} \cos^2(npt + \beta_3) - \frac{b_n^4 M^4}{8} \cos^4(npt + \beta_3)\right] - - - - \tag{12}$$

The first term of this series becomes

$$A\left[1 + \frac{b_n^2 M^2}{4} + \frac{b_n^2 M^2}{4} \cos 2(npt + \beta_3)\right] \tag{13}$$

Hence the original modulation is destroyed and a double-frequency term of the modulation as well as decreasing amounts of higher even order terms arise. If the phase shift β_2 is 0 or $M\pi$ the envelope is,

$$A\sqrt{1 \pm 2b_n M \cos(npt + \beta_3) + b_n^2 M^2 \cos^2(npt + \beta_3)}$$

$$= A\left[1 \pm b_n M \cos(npt + \beta_3)\right] \tag{14}$$

whence there is no envelope distortion but merely a reversal of sign for even values of M which is of no consequence. Hence the result for double sideband transmission is analogous to intercept distortion with respect to the intercept points on the vertical axis which has been modulated up to the carrier position and bears the same relation in phase shift of $\beta_2 - \theta$ or $M\pi$.

If the carrier is located at a point of odd symmetry on the phase characteristic as shown in Figure 3, β_2 will be zero and from equation (8) the received component will be

$$V_3 = A \cos \omega_c t \left[1 + b_n M \cos(npt + \beta_3)\right] \tag{15}$$

and no intercept type of distortion occurs. However the different components of $E(t)$ will not be delayed equally and some envelope distortion will remain. It is thus desirable in facsimile double sideband transmission practice to locate the carrier at a point of even symmetry on the delay characteristic in order to minimize signal distortion.

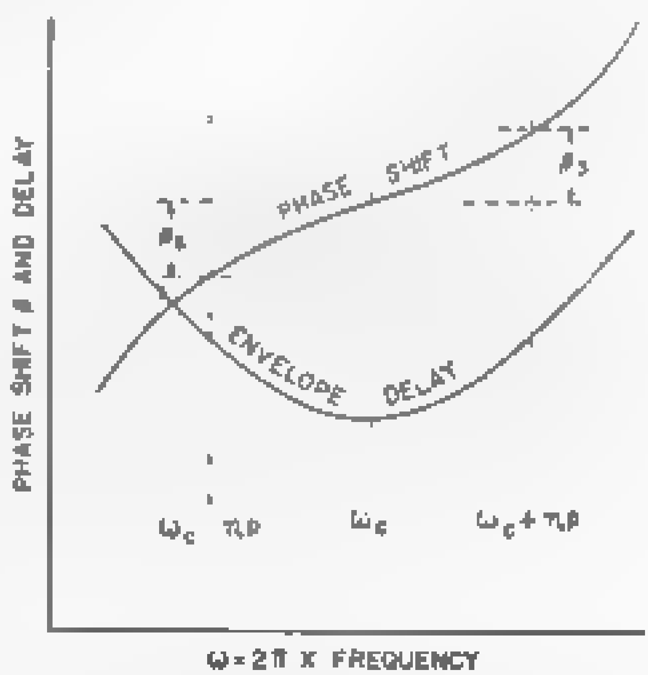

Figure 3. Symmetrical phase and envelope delay characteristics

In the foregoing it has been assumed that the amplitude characteristic is constant throughout the useful frequency range. If both amplitude and delay characteristics are not constant with frequency

other forms of distortion take place. One particular type takes place in the form of echoes which in recorded form results in ghosts. An echo occurs if the amplitude has a cosine variation and the phase characteristic has a corresponding sine variation or conversely with respect to frequency.[4, 5] In this case the spacing of the echo from the original pulse depends upon the spacing of these sinusoidal variations with respect to frequency.

However, it is usually sufficient to make correction only for envelope delay distortion in addition to the usual amplitude correction. It is not necessary to consider phase shift directly as such. When satisfactory correction has been made for envelope delay distortion, it usually will be found that phase delay distortion is within tolerable limits particularly if a sufficient number of carrier cycles exist under the modulation envelope. Accordingly networks have been considered here mainly for the correction of envelope delay distortion.

Corrective Network Characteristics

For the compensation of delay distortion in carrier "vehicle" bands and associated equipment, types of corrective networks which may be readily designed and individually adjusted to meet the conditions of a particular application are required. For use with the delay measuring instrument, they must be readily adjustable either continuously or in small steps to compensate for a deficiency at any point in the useful frequency range. Such networks, generally designated as all-pass, are usually designed to have an amplitude characteristic which is essentially independent of frequency throughout the useful frequency range. These networks may be passive or active. Active networks have a property not possessed by passive networks that the delay characteristic can be readily varied over a wide range, whereas, passive networks that permit the delay characteristic to be varied over the necessary range become impracticably complicated. Also it is the property of some types of active networks that in addition to the adjustable delay feature, the amplitude characteristics may be varied over a limited range to compensate circuit amplitude distortion or amplitude distortion introduced by other networks.

The passive networks usually considered for distortion correction are the constant-resistance recurrent structures designated to match the line impedance.[6] Active networks may be designed for various conditions of input and output terminating impedances and methods of injecting the input and extracting the output. A number of these are given in the following table.

GROUP	SOURCE IMPEDANCE	SOURCE VOLTAGE	LOAD IMPEDANCE	LOAD VOLTAGE
A	Low	Transverse	High	Transverse
B	High	Transverse	Low	Transverse
C	Low	Transverse	High	Longitudinal
D	High	Transverse	Low	Longitudinal
E	Low	Longitudinal	High	Longitudinal
F	High	Longitudinal	Low	Longitudinal
G	Low	Longitudinal	High	Transverse
H	High	Longitudinal	Low	Transverse

It can be readily shown that the transfer function of a delay network having an attenuation or gain which is constant with frequency can be expressed in the form

$$N\frac{A \pm jB}{A \mp jB} = N\underline{/\beta} \tag{16}$$

or other equivalent expressions, where

$$\beta = 2\tan^{-1}\frac{\pm B}{A}$$

N = a constant

A and B are functions of ω and the network parameters. For the present purposes the constant N may be neglected.

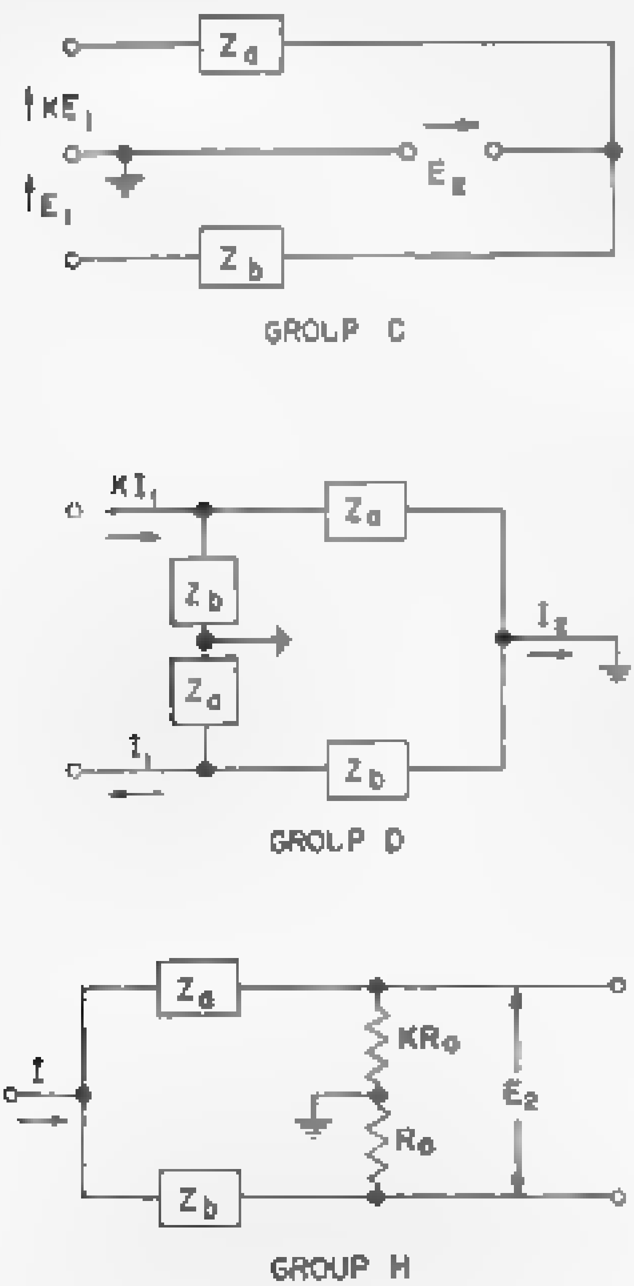

Figure 4. Typical network configurations for Groups C, D and H

In general the groups listed in the table can be realized by a number of network configurations. A typical network configuration for Groups C, D, and H, is shown in Figure 4 for which the output to input transfer ratio is of the form

$$\frac{E_2}{E_1} = \frac{KZ_b - Z_a}{Z_a + Z_b} \tag{17}$$

where

Z_a and Z_b are functions of ω and the network parameters

K is a proportionality factor

The proportionality factor K may be real or complex. However only real numbers will be considered here.

Under certain prescribed relations among the parameters, the factor K may take on integer values. If $K = 1$ equation (17) is directly in the form of equation (16). The result is the well-known delay network in which the conditions are satisfied by a resistance for Z_a and a reactance for Z_b so that

$$\frac{E_2}{E_1} = \frac{jX - R}{jX + R} \tag{18}$$

and

$$\beta = 2\tan^{-1}\frac{X}{R} \tag{19}$$

If $K = 3$ the conditions can be satisfied by the use of a resistance for Z_a and a resistance and reactance in parallel for Z_b so that

$$\frac{E_2}{E_1} = \frac{2jX - R}{2jX + R} \tag{20}$$

and

$$\beta = 2\tan^{-1}\frac{2X}{R} \tag{21}$$

For $K = 5$, the conditions can be satisfied by impedance functions for Z_a and Z_b such as

$$Z_a = R_1 + jX \quad \text{and} \quad Z_b = \frac{jMR_2X}{R_2 + jMX} \tag{22}$$

where

M = a constant

However, a very useful form occurs when $M = 1$ and $R_1 = R_2 = R$ in which the output-input transfer ratio is

$$\frac{E_2}{E_1} = \frac{3jRX - (R^2 - X^2)}{3jRX + (R^2 - X^2)} \tag{23}$$

and

$$\beta = 2 \tan^{-1} \frac{3RX}{R^2 - X^2} \tag{24}$$

The $K = 3$ and $K = 5$ series of networks are particularly useful in phase shifting and delay networks. A very simple phase shifting network applied to Group C is shown in Figure 5 in which from equation (23)

$$\beta = 2 \tan^{-1} \frac{3\omega RC}{\omega^2 R^2 C^2 - 1} \tag{25}$$

A range for fixed values of ω and C from approximately 0° to 360° is obtained with constant amplitude throughout this range merely by simultaneously varying the two equal resistors R.

The $K = 3$ series has been selected for delay distortion correction where variable delay properties are essential. The schematic arrangement of a section is shown in Figure 6 where the resistor R_1 is used for Z_a and the parallel arrangement of

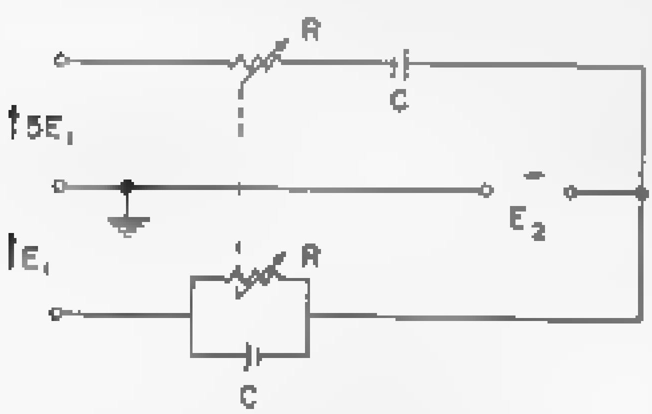

Figure 5. Phase shifting K-5 network applied to Group C

resistor R_2 inductor L and capacitor C is used for Z_b. The $K = 3$ factor is obtained by the divider R_3 and R_4 such that $R_3/R_4 = 3$. The delay characteristic is varied by R_1 and R_2. If these resistors are maintained equal, the delay characteristic will be dependent upon their common value while the amplitude characteristic will remain constant for all settings and from equation (21) β will be

$$\beta = 2 \tan^{-1} \frac{2 \frac{\omega}{\omega_0} \sqrt{L/C}}{\left[1 - \left(\frac{\omega}{\omega_0}\right)^2\right] R} \tag{26}$$

If in addition it is desirable to produce a variable amplitude characteristic, this can be accomplished by offsetting resistor R_2 with respect to resistor R_1. In this case the output-input transfer ratio and delay can readily be shown to be

$$\frac{E_2}{E_1} = \frac{jX(3R_2 - R_1) - R_1R_2}{jX(R_2 + R_1) + R_1R_2} \tag{27}$$

$$\beta = \tan^{-1} \frac{X}{\frac{R_1 R_2}{3R_2 - R_1}} + \tan^{-1} \frac{X}{\frac{R_1 R_2}{R_1 + R_2}} \tag{28}$$

where

$$X = \frac{\frac{\omega}{\omega_0} \sqrt{L/C}}{1 - \left(\frac{\omega}{\omega_0}\right)^2} \tag{29}$$

If R_2 is larger than R_1 the amplitude characteristic, from equation (27), will be peaked upward in the vicinity of the resonant frequency ω_0. If R_2 is smaller than R_1 it will be peaked downward. Thus with these networks it is possible to adjust the delay characteristic over a wide range and the amplitude characteristic over a somewhat restricted range essentially

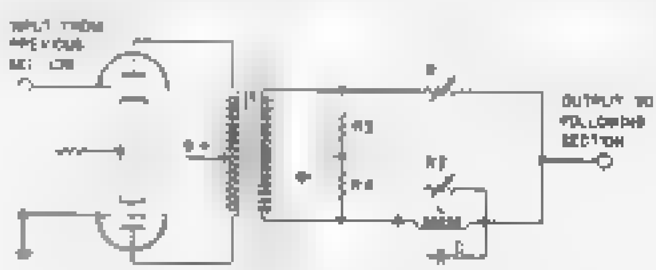

Figure 6. Active corrective network section

independent of each other merely by adjusting two resistors and maintaining a proper relationship between them in accordance with equations (27) and (28). Practically, it is usually necessary to change only R_2 from equality with R_1 to change from a flat amplitude characteristic to a peaked characteristic in the

vicinity of ω_0. This is not possible with passive networks which usually require separate networks for amplitude and delay distortion correction since each alteration of the amplitude characteristic of a purely amplitude corrective network introduces some delay distortion which in turn must be offset in the delay corrective network. For this reason, amplitude distortion correction is usually made first. With the $K = 3$ active network, this process is inherently accomplished.

Application of Corrective Networks

A great variety of delay curve shapes may be encountered among the transmission circuits to be equalized with corrective networks. Not only are there large variations among the different types of circuits, but even the same type requires different amounts of correction throughout the essential frequency range. For any circuit to be corrected, the desired result to be achieved is a uniform amplitude and delay response flat within prescribed limits over the essential bandwidth. Since delay cannot be subtracted from the circuit, the problem resolves itself into one of raising the delay of all points to the vicinity of the highest delay value on the characteristic within the essential bandwidth.

first inserted for a rough correction. After this has been done, the remaining correction may be accomplished with active network sections, filling in those areas where delay deficiencies exist. The ability to vary the delay of each individual section allows much finer adjustments to be made than is practical with passive sections. If after obtaining a refined delay correction, amplitude distortion exists as a result of insufficient amplitude correction, or amplitude distortion inserted by the passive sections, the amplitude characteristic may be corrected with some limitations by offsetting the adjustable resistors of the active network sections as described in the foregoing.

In some applications such as in military circuits, it might be desirable to provide packaged units containing a number of passive sections and other units containing a number of active sections. In this case the units would be left in circuit as adjusted and would be available for making a quick change in case the circuit make-up is altered. In other cases this procedure would not be economical. The preferred method then would be to insert other passive and active sections in the circuit corresponding to the sections in use in the packaged units, or specially select or design passive sections which simulate the combined delay of the passive

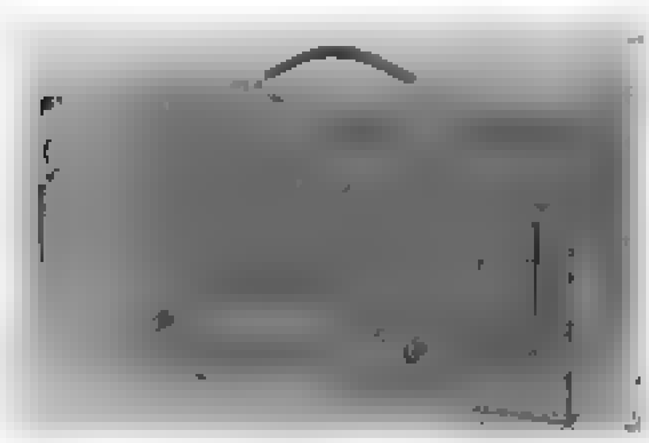

Figure 7. Passive corrective network

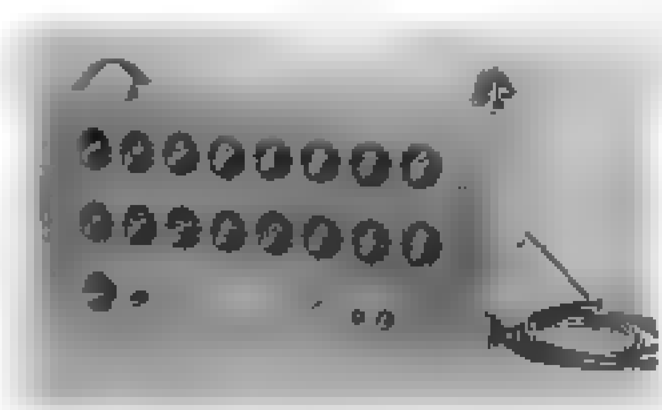

Figure 8. Active corrective network

The application of both passive and active networks is particularly advantageous in conjunction with the delay measuring instrument by which the delay characteristic is continuously displayed. The passive sections, possessing relatively large lumped delay values, preferably are

and active sections. The design parameters can be obtained from the fixed passive values and the active network settings.

In Figures 7 and 8 are shown passive and active units suitable for applications to facsimile circuits as discussed in the foregoing. The passive unit consists of 25

bridged-T sections and an input and output transformer. Each section has a fixed delay distribution and an attenuation at the frequency of peak delay ranging from about 0.8 db in the low frequency sections to about 1 db in the upper frequency sections. The peak delay occurs at selected frequencies ranging from 600 cycles for section 1 to 3000 cycles for section 25. A representative curve of the delay distribution of one section is shown in Figure 9. The sections are arranged in four groups to simulate assigned delay distributions. Switches are provided to permit any group or any combination of sections to be inserted.

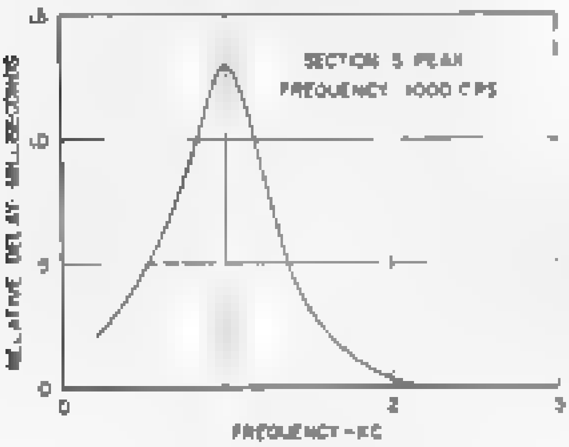

Figure 9. Envelope delay characteristic of a passive network section

tion may be varied in 22 steps from a minimum of about 100 microseconds to a maximum of about 1500 microseconds. When the sections are inserted in tandem, the delay at any frequency will be the sum of the individual section delays at that frequency. The amount of correction inserted may range from about 100 microseconds when only a few sections are in circuit to approximately 3000 microseconds when all sections are included and

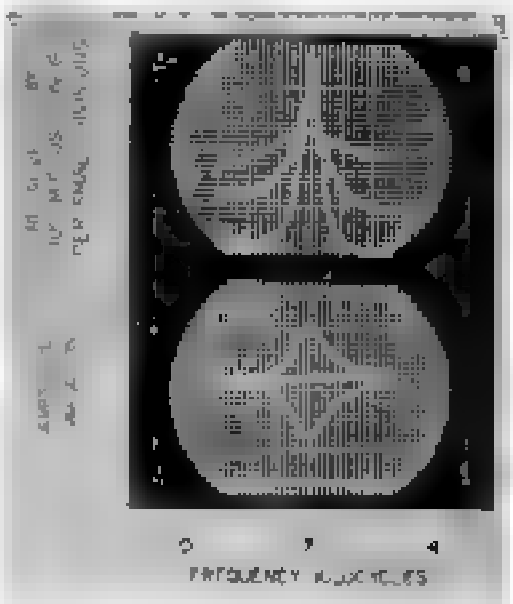

Figure 10. Typical envelope delay and amplitude characteristics of an active network section

The active network unit consists of eight type $K = 3$ sections as shown in Figure 8 with electron tube coupling between sections, an input gain control, and a twin-triode output amplifier stage. The peak delay values of the sections occur at approximately 375-cycles-per-second intervals from approximately 600 cycles to 3200 cycles, with slightly closer spacing around the center of the band. As with the passive network, each section may be individually inserted or omitted for any circuit correction. Toggle switches are provided on the panel of the unit for this purpose. In addition to providing individual section selection, this unit has the additional advantage of individually variable delay for each section. The delay is varied with two rotary switches and two toggle switches appearing between the two rotary switches for each section. With these controls the peak delay of any section may be varied in 22 steps from a minimum of about 100 microseconds to a maximum of about 1500 microseconds.

set at their maximum peak delay values. When it is desirable to change only the delay distribution, the switches are set in pairs with the switches of each section at the same switch position. If in addition it is desirable to make an amplitude correction in the vicinity of the section peak delay frequency, the lower rotary switch of a pair is set forward for an increase in amplitude and backward for a decrease in amplitude. Representative curves of the delay and amplitude distributions of one section are shown in Figure 10. Here the delay curves are displaced vertically with respect to each other to show clearly their distribution. The three delay curves depict settings as provided in the active unit near the minimum, intermediate and maximum peak delay values. The amplitude curves correspond to the intermediate delay distribution for a flat amplitude characteristic, and for inter-

mediate amplitudes peaked upward and downward

In addition to their use in effecting a particular delay distribution at constant amplitude, these units also have the property that various amplitude distributions can be simulated at an essentially constant delay. For example, by proper switch settings a vestigial filter amplitude characteristic can be simulated at constant delay throughout the effective bandwidth.

Results of Distortion Correction

Facsimile and data processing equipment is required to operate satisfactorily over various types of commercial and military circuits, and various combinations of these circuits. These transmission facilities consist of various physical, carrier, and radio circuits having a wide range of envelope delay distortion and often an appreciable amount of amplitude distortion. The over-all frequency range necessary to provide satisfactory operation depends upon the type of equipment employed, and such factors as double or vestigial sideband operation, etc. In general the transmission band most frequently employed extends from about 600 or 800 cycles to about 3000 cycles for the most important frequencies contained in the signals. Frequencies involved in transmission near the carrier frequency are usually of greater importance than frequencies remote from the carrier frequency.

For application to facsimile circuits, a number of corrective sections are connected in tandem, usually at the receiving end of the circuit, the number depending upon the type of delay characteristic to be corrected. These sections are spaced at frequency intervals throughout the band as required to fill-in a delay deficiency, and each active section is adjusted so that the combined delay of all sections is the desired delay compensating characteristic. In general, relatively broad individual curves spaced far apart are required when the delay to be corrected is small in value. Where a large value of delay needs to be corrected, relatively steep delay curves can be used with the sections spaced at small frequency intervals.

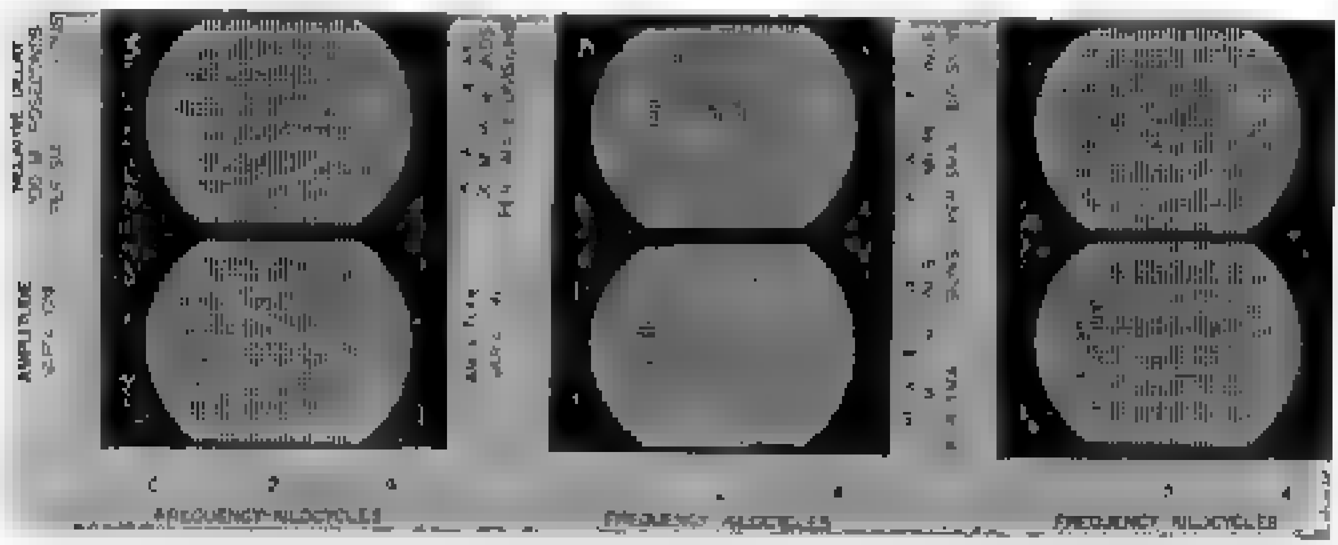

Figure 11. Delay and amplitude characteristics of a 44-millihenry per mile loaded cable — uncorrected

Figure 12. Delay and amplitude characteristics of a 44-millihenry per mile loaded cable — corrected

Figure 13. Delay characteristics of a radio beam circuit — uncorrected and corrected

In Figure 11 are shown the delay and amplitude characteristics of a 44-millihenry per mile loaded cable circuit approximately 125 miles in length. This circuit was corrected using the active network alone with the result as shown in Figure 12 in which the delay characteristic is flat within the usual allowable tolerance of ± 250 microseconds from approximately 500 to 4000 cycles. A rough amplitude correction was obtained by use of the active network as shown by the

lower traces of these oscillograms. It should be noticed that since amplitude can be either added or subtracted, in the corrective process the amplitude was decreased for the lower frequencies and increased for the upper frequencies by the active networks. Likewise, in Figure 13 are shown results as obtained on a radio beam circuit approximately 200 miles in length. The upper curve of this oscillogram is the delay characteristic without correction and the lower curve is the delay characteristic after correction has been applied. The corrective process is well illustrated by the oscillograms of Figures 14, 15 and 16 using a long Type-K carrier circuit. In the first mentioned figure are shown the uncorrected delay and amplitude characteristics. In the second, the delay characteristic has been corrected, and in the third, a partial amplitude correction has been obtained. It should be pointed out that in making the amplitude correction the delay characteristic was unaffected and that for all practical purposes the delay and amplitude corrections can be made independently of each other.

These networks provide a readily adjustable means for obtaining various delay characteristic shapes in addition to those normally present in facsimile circuits for the appraisal of facsimile recorded copy with respect to delay distortion. A large number of such test conditions have been investigated comprising various tolerances from a mean value. For the loaded physical circuit, Figures 11 and 12, facsimile operation is considerably improved by distortion correction. For Type-K circuits, distortion correction may give sufficient improvement to permit operation at double speed with vestigial operation as compared to double sideband operation with the carrier near a point of even symmetry on the delay characteristic. Also, delay distortion correction may permit splitting the normal voice band circuit into two subbands so that normal operating speed can be obtained in each of these bands using vestigial operation. In general, the appraisal of the various factors involved indicates that the tolerance limit for satisfactory facsimile operation is of the order of ±400 microseconds from the mean value per 1000 cycles of modulation (inverse relationship); whereas, the usual quoted value is generally ±250 microseconds.

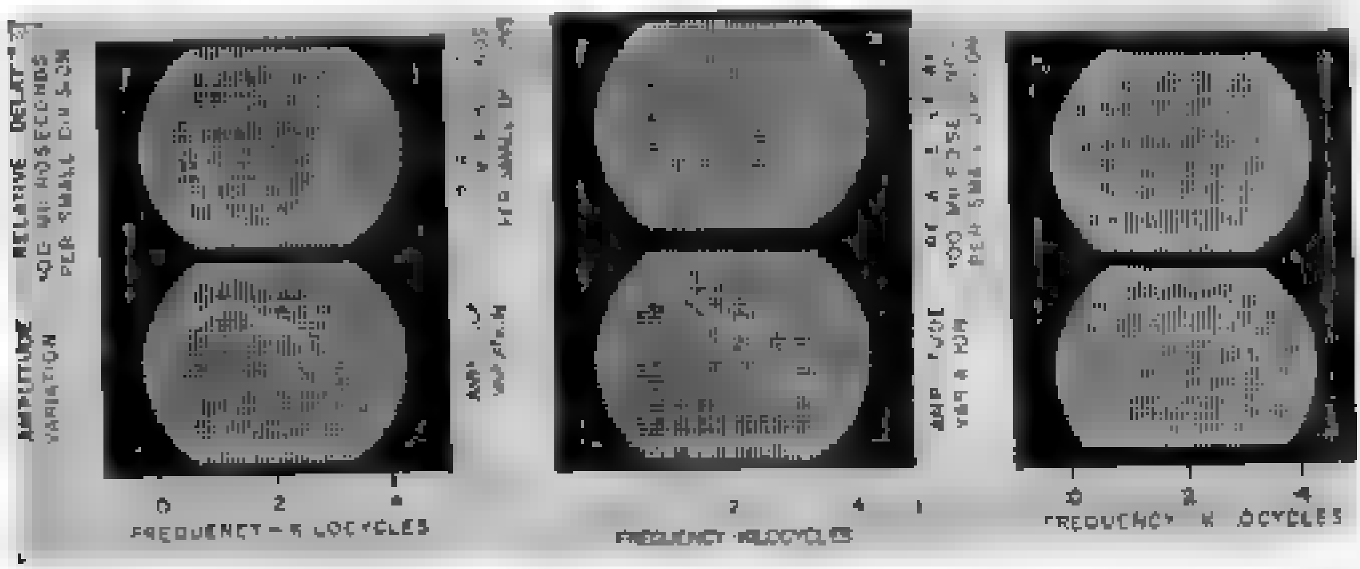

Figure 14. Delay and amplitude characteristics of a type-K carrier circuit — uncorrected

Figure 15. Delay and amplitude characteristics of a type-K carrier circuit — delay corrected, amplitude uncorrected

Figure 16. Delay and amplitude characteristics of a type-K carrier circuit — corrected

The development of the instrument described in this paper was one phase of a comprehensive investigation of delay distortion and correction conducted by the Western Union development and research organization under U. S. Army Signal Corps sponsorship.

Acknowledgment

The author gratefully acknowledges the guidance and assistance of many people concerned with the measurement and correction of delay distortion. Special thanks are given to Henry F. Burkhard and Chester S. Friedman of the U. S. Army Signal Corps, and F. B. Bramhall, Transmission Planning Engineer, Albert Boggs, Assistant to Radio-Wire Transmission Engineer, and D. J. Bertuccio, of the Western Union Telegraph Company.

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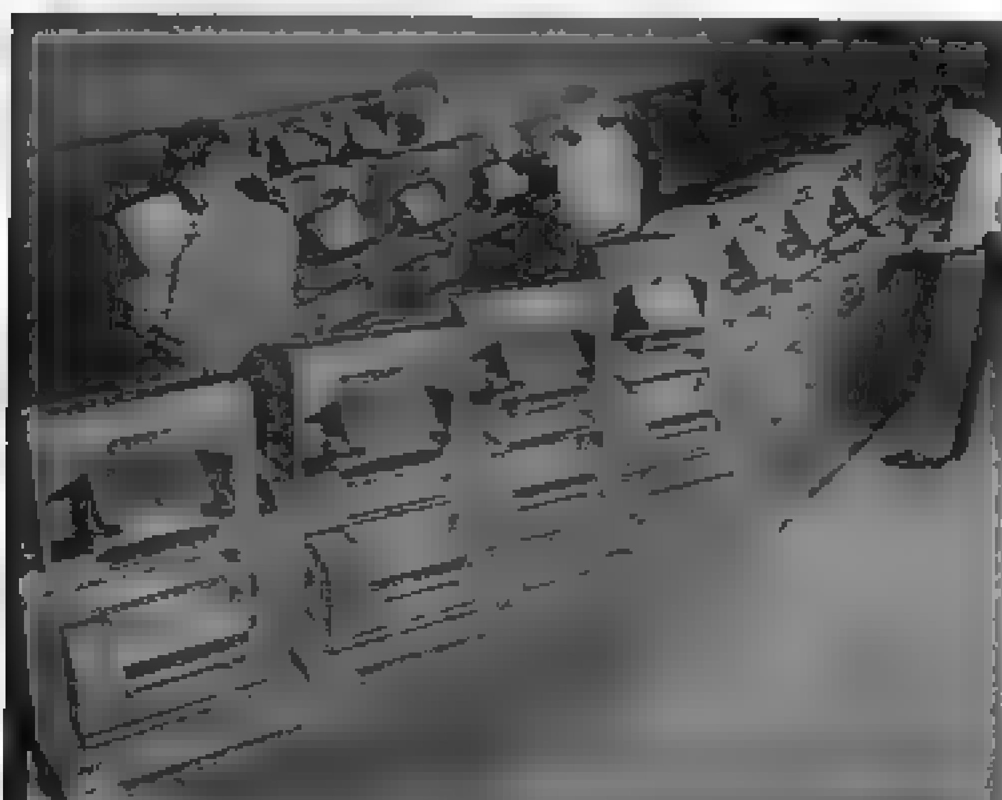
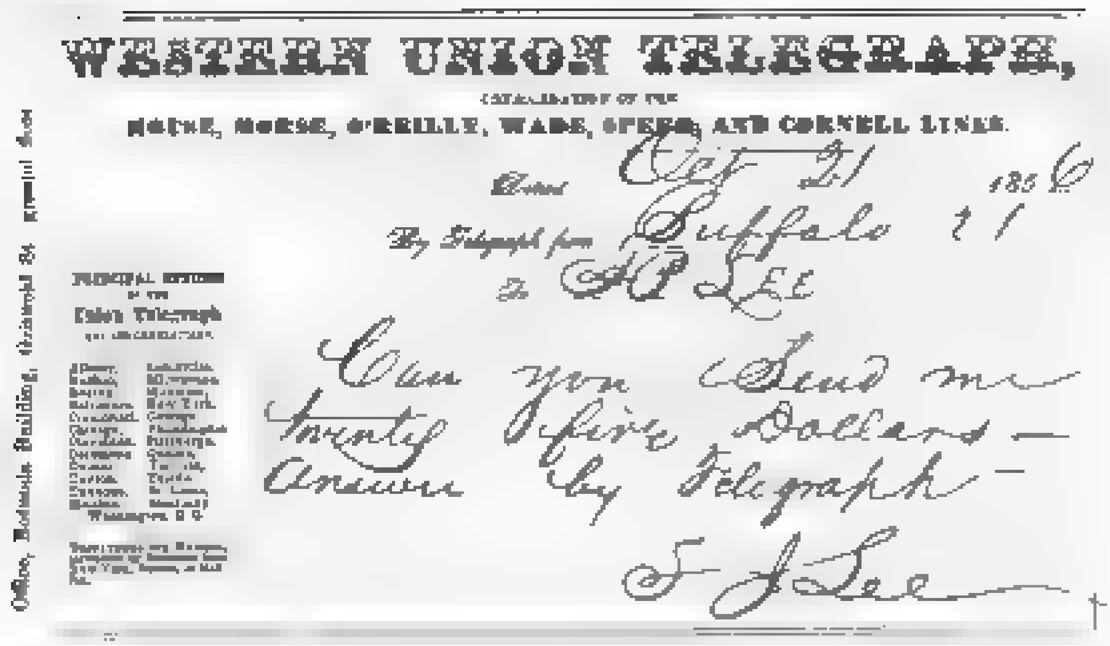
Intrafax Machines Placed On Test



Western Union Telefax equipment is tested in operation before installation for the Federal Reserve Bank's private wire facsimile network serving 12 other banks



WESTERN UNION TELEGRAPH,

CONSOLIDATION OF THE

HOUSE, MORSE, O'REILLY, WADE, SPEED, AND CORNELL LINES.

Dated Oct 21 1856

By Telegraph from Buffalo 21

To H P Lee

Can you send me twenty five Dollars — Answer by Telegraph —

S J Lee

Telegram of 1856, the year that "Western Union" was named

1856 "Western Union" Centennial 1956

The great city of Rochester in New York State has attained distinction and repute in many ways and for many reasons. The Western Union Telegraph Company is proud indeed to acclaim that city as its own birthplace and is gratified to be able to point out that its own expansion and modernization has paralleled that of this virile American city for over 100 years.

The name Western Union, signifying a combination of Western lines in one system, originated in Rochester after Ezra Cornell, for whom a renowned university is known, agreed to consolidation of his telegraph interests with those of the New York and Mississippi Valley Printing Telegraph Company, a vigorous, well-managed enterprise whose headquarters were at Rochester. The Mississippi Valley Company had been organized there in 1851 to exploit an ingenious, complicated, but nevertheless practical, electro-mechanical printing telegraph system patented in 1846 by Royal E. House of Vermont.

In those days, of course, all of the area westward of Rochester and the Atlantic Seaboard generally was "out west." There were few if any telegraph lines beyond the Mississippi, except those in California, so actually this "Western Union" consolidation was mainly effective in five states north of the Ohio river. Although perhaps not fully comprehended at the time, it developed that the Morse patent rights for western territory and the other-line connections contributed to the consolidation by Cornell's Erie and Michigan Telegraph Company were of great worth.

Telegraph historian James D. Reid wrote in 1877 of early days in Rochester that the city "had in its citizenship a number of men of exceptional energy, of quick discernment, plucky, enterprising, with the dash, tact and boldness peculiar to pioneer characters. There was also another element to be found there in large degree, which, while it shared the boldness of the former, added thereto the polish and scholarliness and delicacy of society in its best conditions. Rochester was the center of a large, populous, fertile region. The Genesee Valley was long famous for its rich harvests, and for the vivacity and intelligence of its population. George Dawson, Henry R. Selden, Samuel L. Selden, Addison Gardiner, Isaac R. Elwood, Henry O'Reilly, Freeman Clarke, Harvey Ely, Hiram Sibley, Alvah Strong, Levi A. Ward, George H. Mumford and O. H. Palmer, were among its prominent citizens."

Thus Rochester appears to have numbered among its residents many energetic, enterprising and able men among whom were Judge Samuel L. Selden and Hiram Sibley whose joint efforts led first to successful establishment of the Mississippi Valley Company and then, five years later, on April 4, 1856, to the consolidated Western Union system that was to provide the nation with its telegraph communications in peace and war for the next 100 years.

RONALD S. WISHART, Assistant Systems Planning Engineer
GEORGE STRUNZ, JR., Project Engineer, Systems Planning

Small Terminal Office Reperforation

During 1954 a field trial installation of small office reperforator switching equipment was made at Passaic, N. J. It is the purpose of this article to describe some of the thinking that brought about such an installation and the modifications that occurred as a result of the field trial. Included is a general description of the operation of the small terminal office switching arrangement.

OPERATION of the nationwide Western Union public message system is based upon the division of the country into fifteen switching areas made up of individual states or groups of states. Each of these areas contains a reperforator switching center interconnected with other centers. These switching centers serve the city in which they are situated and all tributary offices in their area. Figure 1 shows this system of operation in diagrammatic form.

Much has been written in TECHNICAL REVIEW describing the operation of reperforator switching centers and enumerating the advantages gained from reperforator operation. Inasmuch as over 90 percent of the telegrams received at a switching center are relayed to their ultimate destination, all messages are received in the switching aisles or at automatic relaying racks in perforated tape form to expedite their movement through a center.

As shown on Figure 1, five types of destinations are possible for telegrams leaving the reperforator center. At the first of these destinations, namely, other reperforator centers, messages may again be received and relayed in perforated tape form. Likewise, at 346-A tables[1] messages are relayed in perforated tape form to their ultimate destination, a printer in the customer office.

At branch offices and locals a teleprinter copy of a message is produced. Generally at these two locations no further relaying of traffic is needed except in the case of a few branch offices where facsimile tie lines have been terminated and in any case the printed copy of a message is all that is required. However, at the fifth destination, the tributary or terminal office, telegrams must be relayed to tie lines, branch offices, and agencies. This

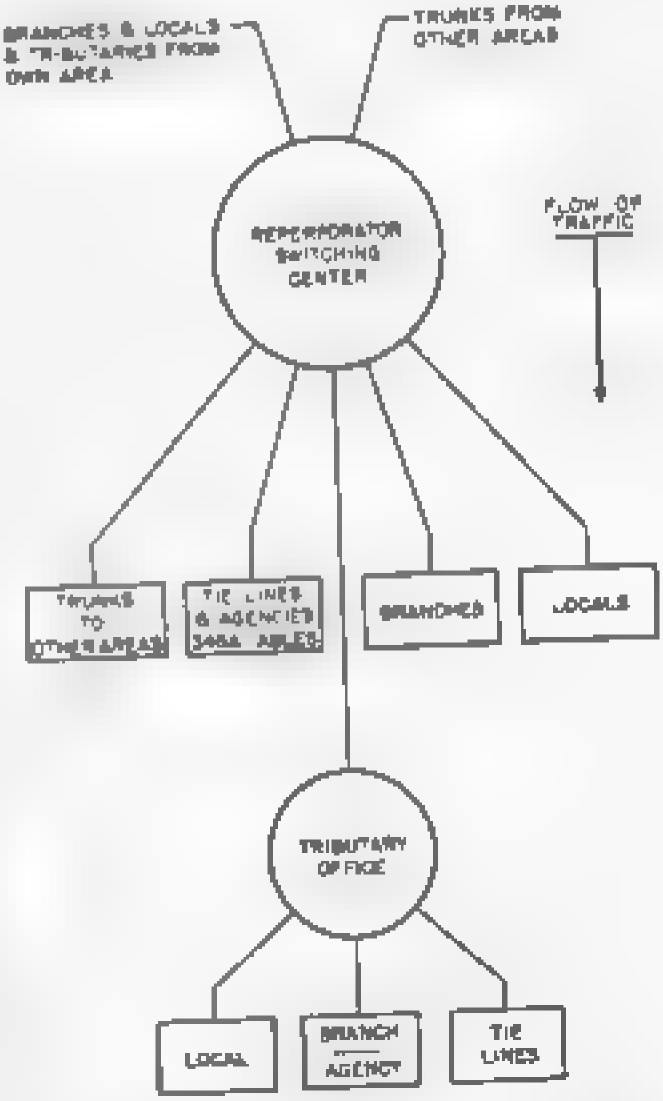


Figure 1. Reperforator switching center and tributary office connections

is regularly performed as a manual relay, involving gumming down the printed tape for each telegram, then transporting the telegram to a sending position and manu-

ally retransmitting it to the proper destination. Here, then, appears to be a logical place to apply reperforator methods for service improvement.

Unlike other points at which reperforator switching has been employed, at the tributary office the percentage of received messages requiring relay usually is relatively small. The remainder of the received load must be in final form ready for delivery by telephone, messenger or Desk-Fax tie line. While there is a definite gain in being able to switch messages which must be relayed, the switching of messages into a secondary position adjacent to a switching position in order to produce delivery copies is wasteful of equipment, time and effort. Instead, an arrangement which produces both a printed copy and a reperforated tape of each message will make the most satisfactory operating scheme for terminal offices where the various operating positions are closely associated physically.

Figure 2. Teleprinter with automatic message cutting and ejecting device

Since the greatest improvement in message handling will occur on relayed messages, the most likely place for successful terminal office reperforation is in an office having a sizable percentage of switchable messages. One such office, for example, is located at Passaic, N. J., with approximately 30 percent of its received telegrams destined for teleprinter tie lines or agencies.

To make the handling of the printed copies as simple as possible, an automatic cutoff page printer (Figure 2) was developed. The theory of operation contemplated at this point was that a page printer copy and a perforated tape copy of each message would be received simultaneously at the terminal office. The tape of switchable messages would be used to relay messages to tie lines and the corresponding page copy retained as a file and accounting copy. The page copies of other messages would be utilized the same as the gummed delivery copies previously

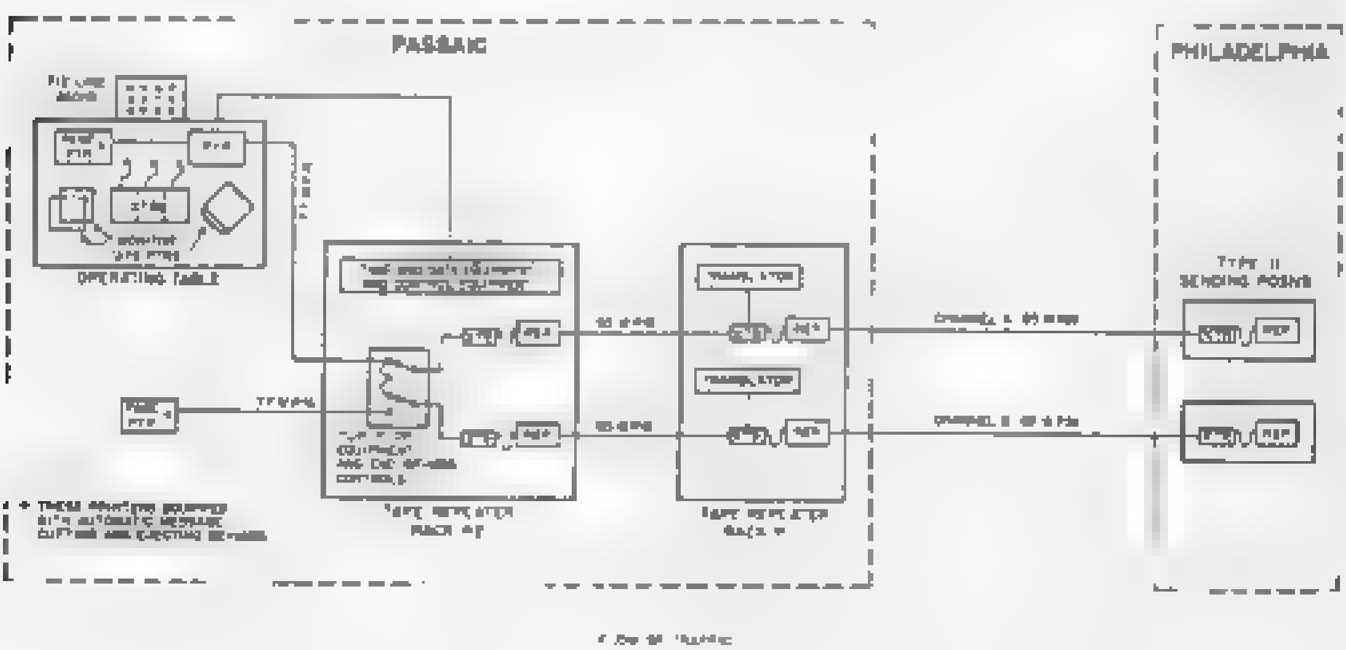


Figure 3. Block diagram of small terminal office reperforation

were, and the corresponding perforated tapes of these messages discarded

To accomplish the desired objectives, equipment to perform several functions is required as indicated on Figure 3. First, it is necessary to translate the received traffic into page form since messages transmitted in the nationwide system are in form for tape printer reception. The equipment to perform this function (tape repeater rack No. 1) for the two receiving channels at Passaic is shown at the right in Figure 4.

Figure 4. Tape repeater racks—Rack No. 2 left, Rack No. 1 right

Another rack of equipment (tape repeater rack No. 2, Figure 4, left) is provided to accomplish several other functions. At this rack perforated tape messages are received in page form. Here, enough "line feeds" are added automatically at the end of each message to produce a 5½-inch long telegraph blank or a multiple thereof. Also, an "upper case blank" is added following the line feeds. The purpose of the blank will be described later. Transmission into this tape repeater rack is at 65 words per minute and transmission from the rack is at 77 words per minute. This speed differential is provided to prevent a backlog of messages from occurring because of the characters added to each received message by tape-to-page translation, line-feeds to produce standard length messages, and cutoff signals. A switch is provided so that either the transmitters send individually over two circuits, or they may be made to "flip-flop" into one circuit leaving the rack. Also located on this rack is a time and date chronitor used in connection with switching to tie lines.

The operating table shown in Figure 5 is basically a 346-A tie-line switching table to which a page printer has been added. Arrangements are provided so that messages are received at this table simultaneously on the page printer and printer perforator from the A and B channels alternately, or from the A channel or B channel continuously. Except in peak load periods, both channels are caused to terminate at this position. The page printer on this table consists of a type 15 page printer as in Figure 2 with a message cutter knife and ejector. The upper case blank at the end of each message, referred to earlier, causes the cutter to operate and the ejector to deposit the received message in the message accumulator attached to the rear of the printer.

The operator at this switching table scans the received page copies. If a telegram is destined for a tie-line patron the corresponding tape is secured for that telegram and standard procedure for switching to tie lines is followed. The page copy is filed with an endorsement indicating that the message has been transmitted. If a message is not to be switched, the corresponding tape is discarded and the page copy used as a delivery copy.

A special masking lacquer is provided to aid in the correction of typing imperfections in messages which must be delivered. This lacquer is the same color as the message blank. It is fast-drying, and corrections may be made immediately by typing over the lacquer.

During peak load periods, notwithstanding the differential between incoming and outgoing speeds, a backlog of messages may accumulate at tape repeater rack No. 2 when the channel alternating arrangement is in use. In this case, one channel is diverted to another automatic cutoff page printer located beside the switching table. Since the installation at Passaic is purely a trial assembly no corresponding perforated tape is produced at this position, and any tie-line messages arriving at this printer are manually transmitted to tie lines.

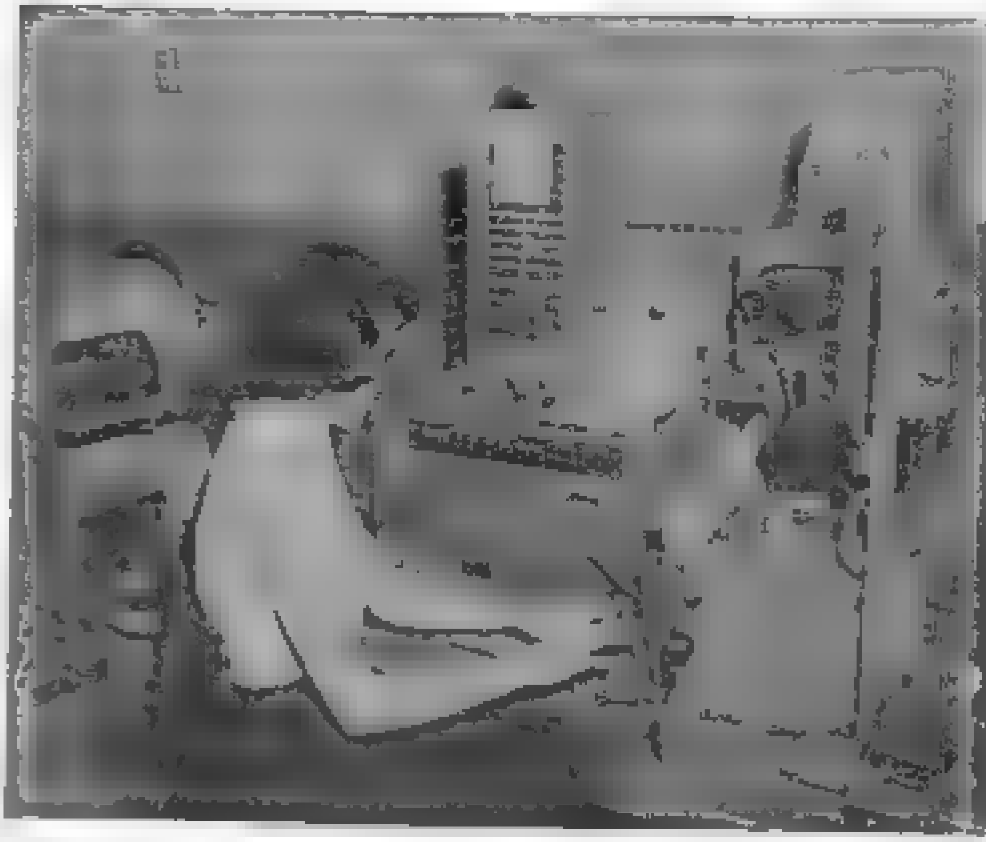


Figure 5. Trunk receiving and tie-line switching position at Passaic, N. J.

A study of the operation of this installation showed considerable improvement over manual methods. However, as a result of the test further changes are proposed to provide greater benefits than are now being attained. By performing the translation and standard message length functions at the reperforator office sending position, a considerably decreased investment charge and improved maintenance can result. The channels from the reperforator office to the terminal office may be operated at 65 or 77 wpm depending upon the load requirements. Additional improvement is possible in the terminal office by terminating both channels in printer perforators as well as in printers. This will produce perforated tapes for all tie-line messages, eliminating all manual transmission to tie lines.

New equipment is now being designed to incorporate these changes and it is anticipated that the first of the new installations will be effected during 1956. The new installation will also have the advantage of requiring less translation since keyboard standardization between tape and page equipment will be in effect at that time. In addition, page printers using message "bursters" rather than knife cutters also will be provided, eliminating the need to generate and transmit a cutoff signal at the end of each telegram.

The new arrangement will utilize sprocket feed fanfold paper, cross-perforated at intervals equal to a 5½-inch long telegram blank. As each of these cross perforations pass through the "burster" the messages are torn apart to produce standard size telegrams.

The field trial at Passaic has shown that appreciable improvements in operation at small terminal offices can be effected by the application of reperforator methods. The tape relay of the messages has noticeably improved the origin-to-destination speed of service. Fewer individual teleprinters are needed to serve the same number of tie lines. The operating section of the office is more compact and manual transportation of messages is reduced to a minimum.

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Ronald S. Wishart, Assistant Systems Planning Engineer acquired his education in Scotland, France, England and the United States. Entering the service of the Postal Telegraph Company in 1907 he served as printer attendant and later as Automatic Chief Operator in New York. With the introduction of Morkrum apparatus in the Associated Press, he became Chief Operator in that service. During World War I he served with the Signal Corps in Europe and later worked with the Morkrum Company (now Teletype) which he represented in Europe from 1919 to 1922. In 1924, Mr. Wishart returned to Postal as Printer and Automatics Engineer and subsequently held various positions including those of Central Office Engineer, Inside Plant Engineer and Chief Engineer. Since the merger of Postal with Western Union in 1943, Mr. Wishart has contributed much to the development and expansion of reperforator switching systems. He is a Member of AIEE.

George Strunz, Jr., Project Engineer with the Systems Planning division, was graduated from Worcester Polytechnic Institute in June 1948 with a degree of Bachelor of Science in Electrical Engineering. he had previously served in the U. S. Navy as an Electronic Technician's Mate. Immediately after graduation he joined the Systems Development and Statistical Engineering Division of Western Union. Since coming with the Telegraph Company Mr. Strunz has been primarily concerned with statistical research and study in connection with switching and other systems developments.

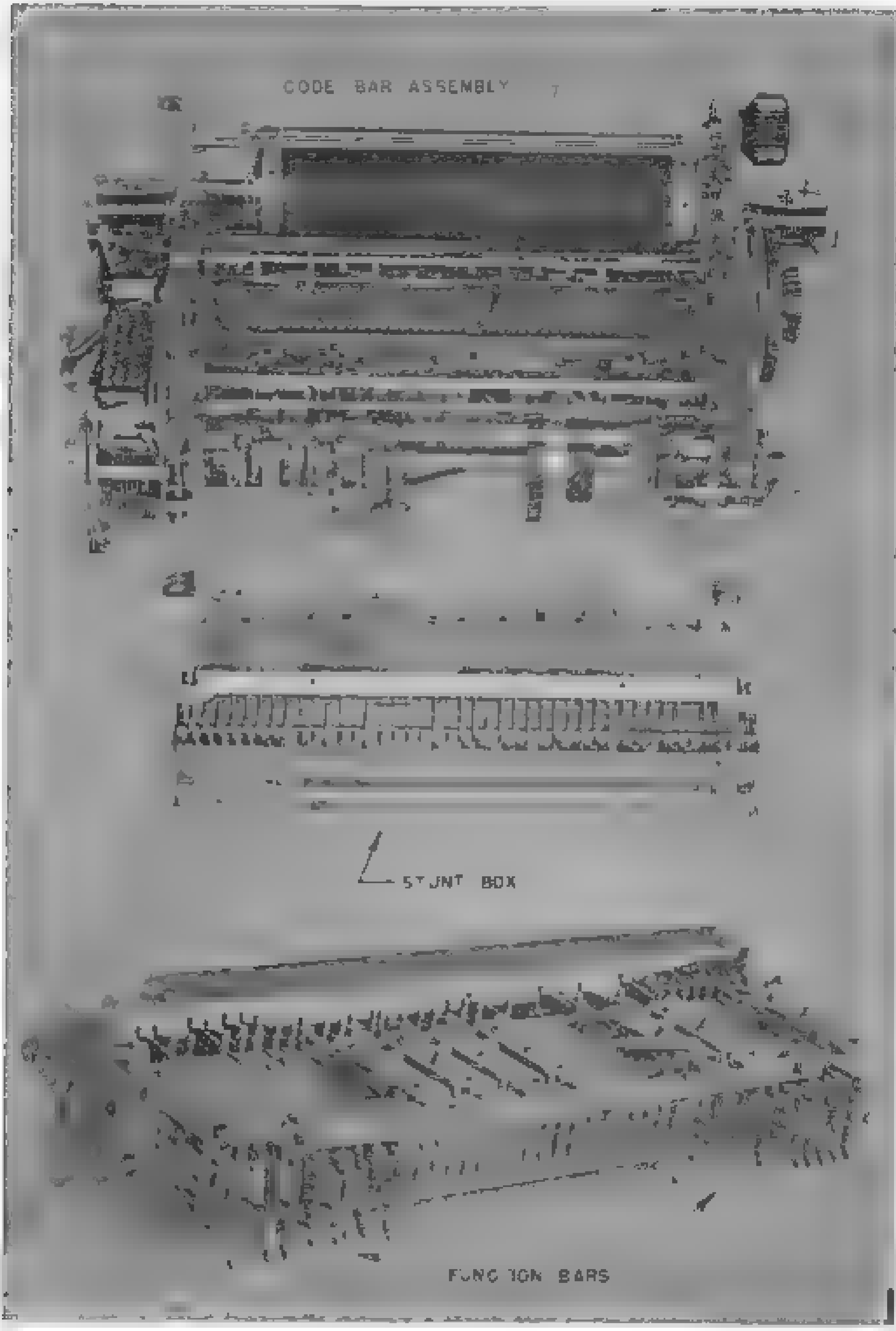

Figure 1 Model 28 typing unit with stunt box removed (top), stunt box, and (below) view of stunt box showing function bars

E. LOUIS PARKINGTON, Field Engineer, Kansas City, Mo.

Function Mechanisms of the Model 28 Teleprinter

Adaptability of the Model 28 teleprinter to a wide variety of special telegraph requirements is owing in large measure to the versatility of its stunt box and the numerous functions that it can accomplish. As the author points out, however, the usefulness of the Model 28 can be attributed not only to the many functions which the stunt box makes possible but also to features such as automatic feed-out or indexing, horizontal tabulation and high operating speed. All are important considerations in an era of expanding use by industry of Western Union's specially engineered private IDP (Integrated Data Processing) telegraph systems for automatic transmission of up-to-the-minute sales, production, payroll and other control data in addition to message services.

In view of increasing industrial record communications requirements for fast data processing, knowledge of the devices with which such requirements are being met is important.

With increasing utilization of Model 28 teleprinters in Western Union private wire services, more and more use is being made of the versatile stunt box which is an essential part of this teleprinter. New uses are being found for this unit in way-station selector operation, in automatic control of associated apparatus and in integrated data processing. This article reviews the theory of operation of the stunt box and describes the various special functions which can be performed by this unit. The general description and theory of operation of the Model 28 teleprinter was covered in the July 1955 issue of Technical Review.[1]

Code Bars

The Model 28 teleprinter stunt box (Figure 1) extends across the entire width of the teleprinter and is mounted directly behind the code bar assembly in the rear of the teleprinter.

There are nine code bars in the teleprinter (Figure 2). The first, second, third, fourth and fifth pulse code bars are positioned to marking or spacing, that is, to the left or to the right as viewed from the front of the teleprinter, by the selector mechanism. The positioning of the common code bar is determined by the position of the first and second pulse code bars, and has no other function than the vertical positioning of the type box as described in the article covering the basic operation of the teleprinter. The suppression, zero, and letters-figures shift code bars are positioned to marking or spacing by functions in the stunt box.

The code bars have two separate and distinct functions. First, after having been positioned for a particular character by the selector mechanism, they cause the type box positioning mechanism, by means of suitable mechanical linkages, to position the type box with respect to the printing hammer so that the character whose code is set up on the first, second, third, fourth and fifth pulse code bars will be printed. Second, they cause functions to be performed within the printer mechanically, or at a remote location by means of an electrical switch. This is accomplished by selecting coded function bars (Figure 3) by means of the notches that are cut uniformly on the rear edge of the code bars.

Function Bars

A function bar, as seen in Figure 3, is designed with tines or projections that are bent either to the right, marking, or to the left, spacing, as viewed from the top. A marking tine will be opposite a notch in the code bar if the code bar is in the marking position, but will be opposite a projection on the code bar if the code bar is shifted to the spacing position. Similarly,

In early telegraph printer days, functions such as line feed, carriage-return and the like were termed "stunts" and actuated through function (or stunt) bars mounted in a "stunt box" assembly hence the designation.

a spacing tine will be opposite a notch in a code bar when the code bar is in the spacing position, but will be opposite a projection when the code bar is shifted to the marking position. By the use of these tines, a function bar can be coded for a particular character so that the function bar will be selected, that is, allowed to enter into the slots in the code bars, when the selector mechanism sets up the code bars for the corresponding code combination of that character. For example the Baudot code combination for the letter "A" is first and second pulses marking, third fourth and fifth pulses spacing. The function bar coded for the letter "A" will have marking tines opposite the first and second pulse code bars, and spacing tines opposite the third, fourth and fifth pulse code bars. There would be no tines on the function bar opposite the other code bars. Under this arrangement, any time the code bars are set up by the selector mechanism for the letter "A", the "A" function bar

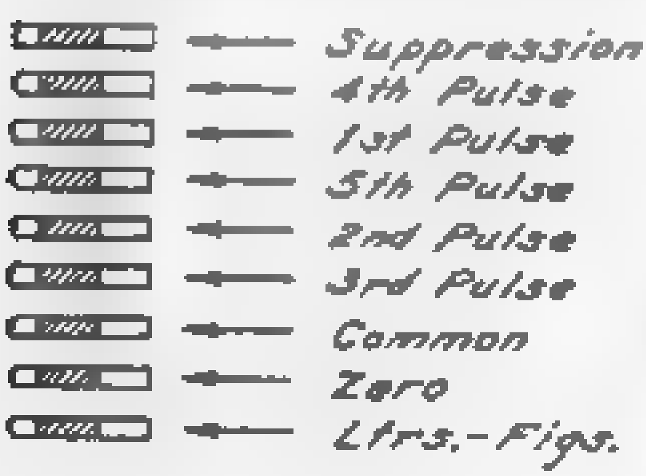

Figure 2. Code bars

will be selected when the function bars are allowed to move against the code bars.

The stunt box has 42 slots, each of which can accommodate a function bar, as pictured in Figure 1. Since the code bars are notched uniformly a function bar coded for any character can be placed in any of the 42 slots. Actually, approximately 7 of the 42 slots are reserved for such essential functions as letters-shift, figures-shift, line-feed, and so forth.

Function Bar Mechanism

A function bar mechanism (Figure 4) consists of a function bar, a function pawl, a function lever, a spring plate, and their associated springs. When the function bar mechanism is in the unoperated position the function pawl rests on top of the rear projection of the function bar as shown in Figure 4

After a character has been set up on the code bars, the function bar reset bail, which extends along the entire width of the stunt box, moves forward allowing all the function bars in the stunt box to feel for an entrance into the code bars. Only the function bar coded for that character will enter the code bars, and the rest will be blocked by a projection on at least one code bar

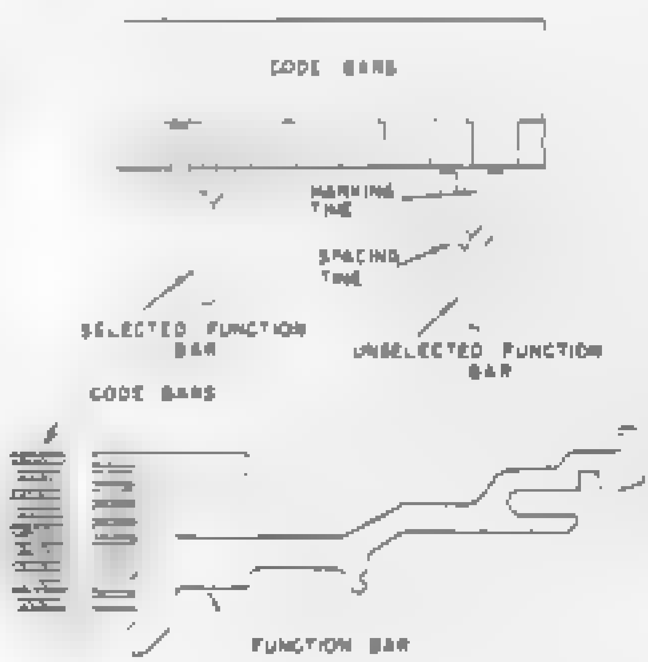

Figure 3. Function bar

When the selected function bar enters the code bars, the notch in its associated function pawl engages the projection on the top of the function bar as shown in Figure 5. The nonselected function bars do not move forward far enough to engage their respective function pawls. As the

function bar reset bail returns the selected function bar to its original position, the function bar carries the function pawl with it. The function pawl has a projection which engages the function lever, and tion levers which were operated by the selected function pawls reach their rearmost position, the stripper blade moves up and strips the function pawls from the function bars,

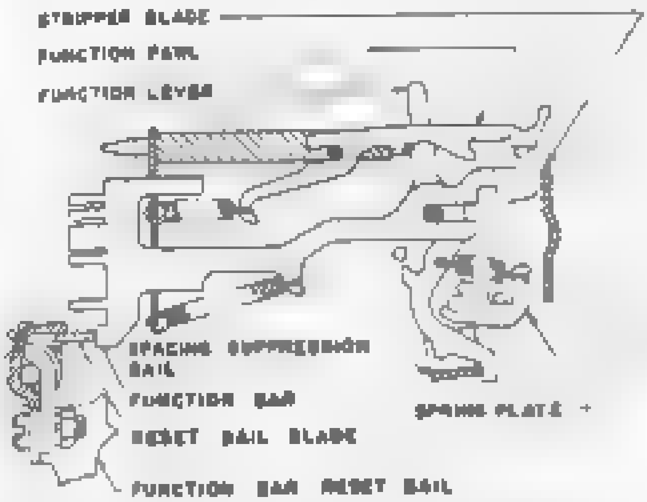

Figure 4. Function bar mechanism not operated

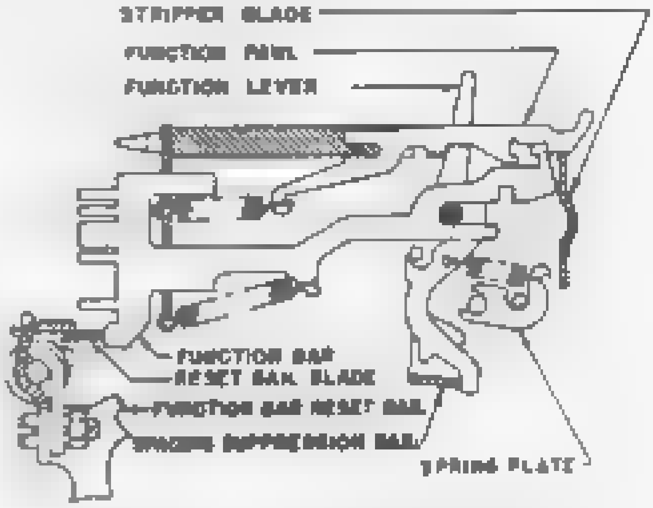

Figure 5. Function bar mechanism operated

rotates it clockwise about its pivot (Figure 5). It is this operation of the function lever that activates the desired function.

A function lever can do work basically in three manners.

1. The lower part of the function lever can operate a slide (Figure 6) which, by means of a suitable mechanical linkage, can create a mechanical action within the teleprinter. For example, Figure 6 shows a function bar coded for the line feed combination. When this function bar mechanism is operated the function lever operates a slide. The slide in turn rotates the line-feed clutch trip arm, thereby allowing the line-feed clutch to rotate in order to perform the line-feed function. At this point the function pawl has to be disengaged from the function bar in order to allow the function lever to return to the unoperated position. This is accomplished by the stripper blade (Figure 5) which extends across the entire width of the stunt box. The stripper blade at the beginning of the operation of the function bar mechanism moves down to allow the function pawls to be moved back by the selected function bars. As the function levers which were operated by the selected function pawls reach their rearmost position, the stripper blade moves up and strips the function pawls from the function bars, thereby allowing the function levers to return to the unoperated position.
2. The top of a function lever can operate a code bar shift mechanism (Figure 7) which in turn will shift a code bar within the teleprinter by means of a post attached to the code bar. Figures 8 and 9 show how the

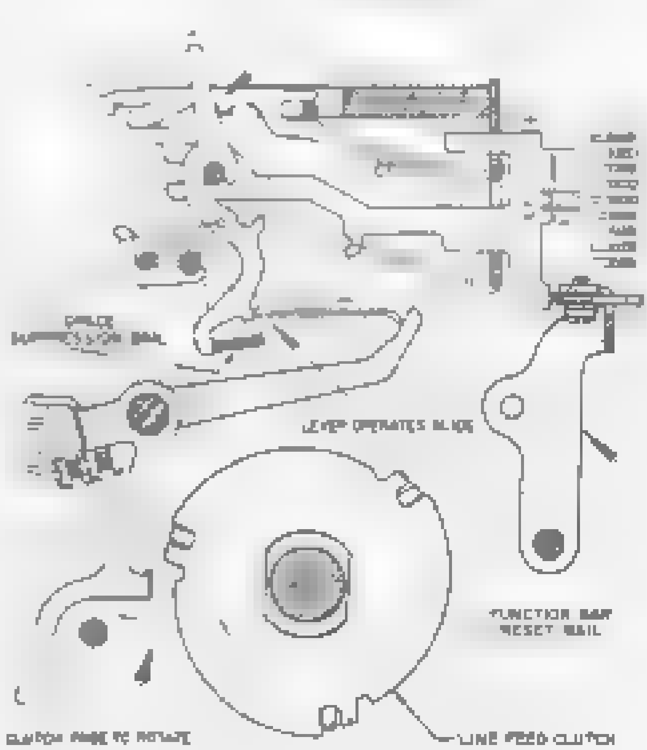

Figure 6. Operation of a line-feed function

letters-figures code bar is shifted by a code bar shift mechanism. The function lever associated with the letters-function slide is activated when its associated function bar, which is coded for the letters code combination, is selected. Similarly, the function lever associated with the figures function slide is activated when its associated function bar, which is coded for the figures code combination, is selected. The position of the letters-figures code bar determines whether the type box will be moved to the letters or figures position. It is now apparent that a function bar can be readily coded for an upper-case or lower-case character by the addition of a marking or spacing tine, respectively, opposite the letters-figures code bar

3. The top of a function lever can operate a switch mechanism (Figures 10 and 11). The contacts in the switch mechanism can be "make" contacts or "break" contacts. The combination of two sets of contacts, one make and one break, can be activated simultaneously to provide "transfer" contacts by means of activating two function bar mechanisms on the same character

Sequential Selection

A function can be performed upon the reception of a sequence of two or more characters, rather than a single character, by the use of a special function lever (Figure 12) which has a blocking and a latching projection. The blocking projection, when the function lever is unoperated, extends over to the adjacent slot in the stunt box, and blocks the function bar in this slot. This blocked function bar now cannot go forward to feel for an entrance into the code bars when the function bar reset bail moves forward. The latching projection is used in conjunction with a function latch (Figure 12) which replaces the spring plate. The function latch has a latching projection which engages the latching projection of the function lever when the function lever is operated. The function latch also has an unlatching projection which is engaged by the stripper blade during the downward motion of the stripper blade

Assume that a function is to be performed if the sequence of the two characters "A" and "B" is received in that order. Two function bars coded for "A" and "B" are mounted in adjacent slots. The function bar mechanism associated with

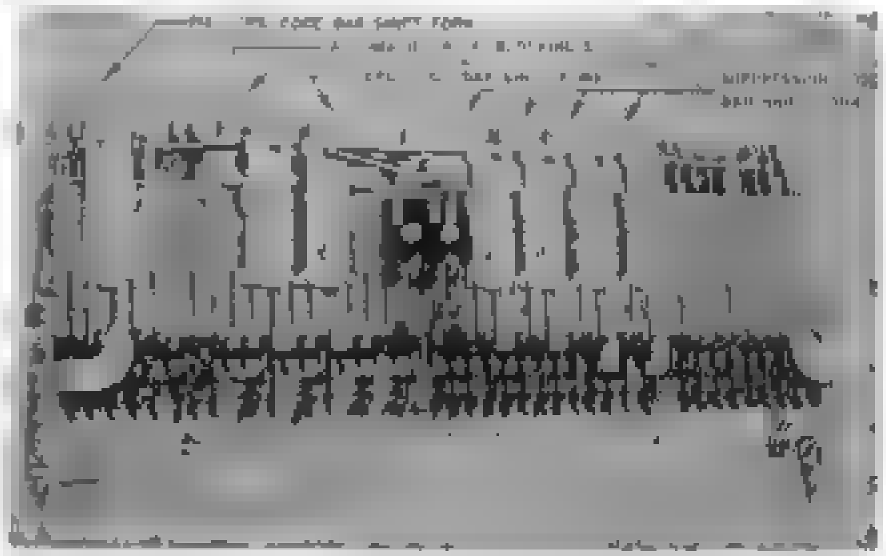

Figure 7. Code bar shift mechanism

the "A" function bar is equipped with a blocking and latching type function lever and an unlatching type function latch. This layout is shown in Figure 13, which shows the "A" function bar mechanism operated, with the blocking projection of the "A" function lever removed from the rear slot of the "B" function bar. This occurs every time the character "A" is set up on the code bars. Assume now that the next character received is a "B." The "B" function bar moves forward into the code bars. At the same time the stripper blade moves downward and unlatches the "A" function bar mechanism. The operation of the "B" function lever activates the desired function. If an extraneous character is inserted between the letters "A" and "B" the "A" function bar mechanism,

upon receiving the "A" character, would latch up and unblock the "B" function bar. During the reception of the extraneous character the stripper blade would unlatch the "A" function bar mechanism and the "B" function bar would be blocked again so that if the "B" character should be received, the "B" function bar mechanism would not be activated. Therefore, the characters have to be received in the proper sequence in order to perform the function.

Remote Control

An electrical switch mechanism activated by a mechanical function in the stunt box can be used for remote control of some associated apparatus. One application of this function would be the requirement of cutting-in a reperforator upon receiving a particular character or a sequence of characters. The switch mechanism to control the reperforator will be activated by the function bar mechanism whose function bar is coded for the "cut-in" character. In case of a sequence of characters, the last function bar mechanism of the sequence will activate the switch mechanism. In order to keep the

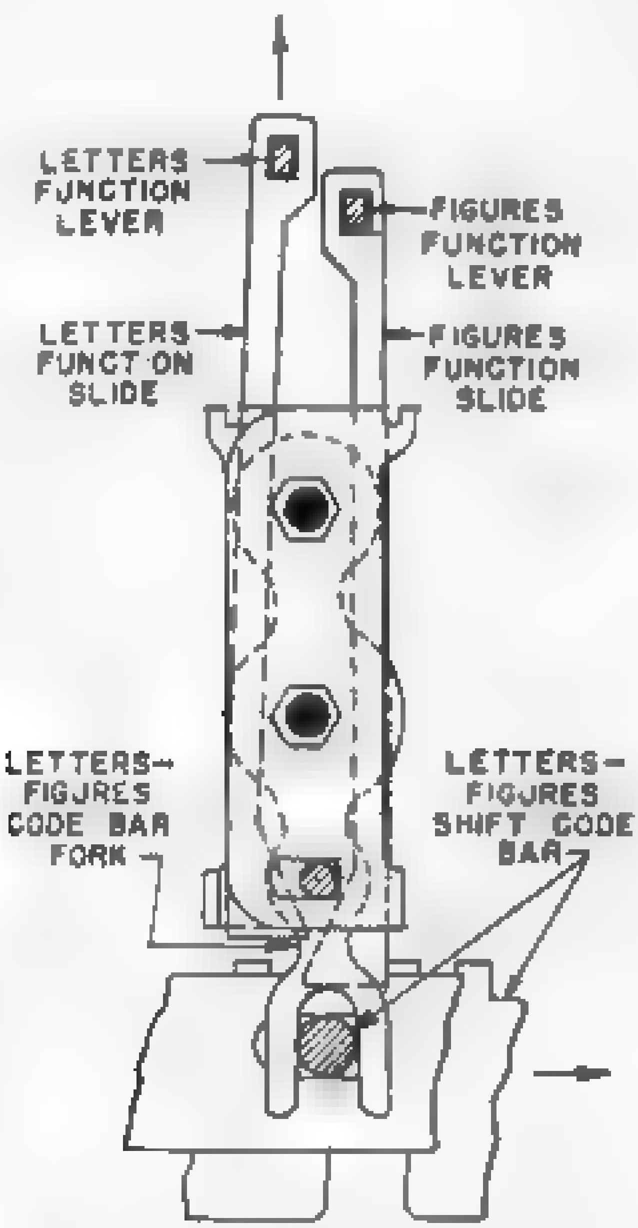

Figure 8. Letters-figures code bar shift mechanism in letters position

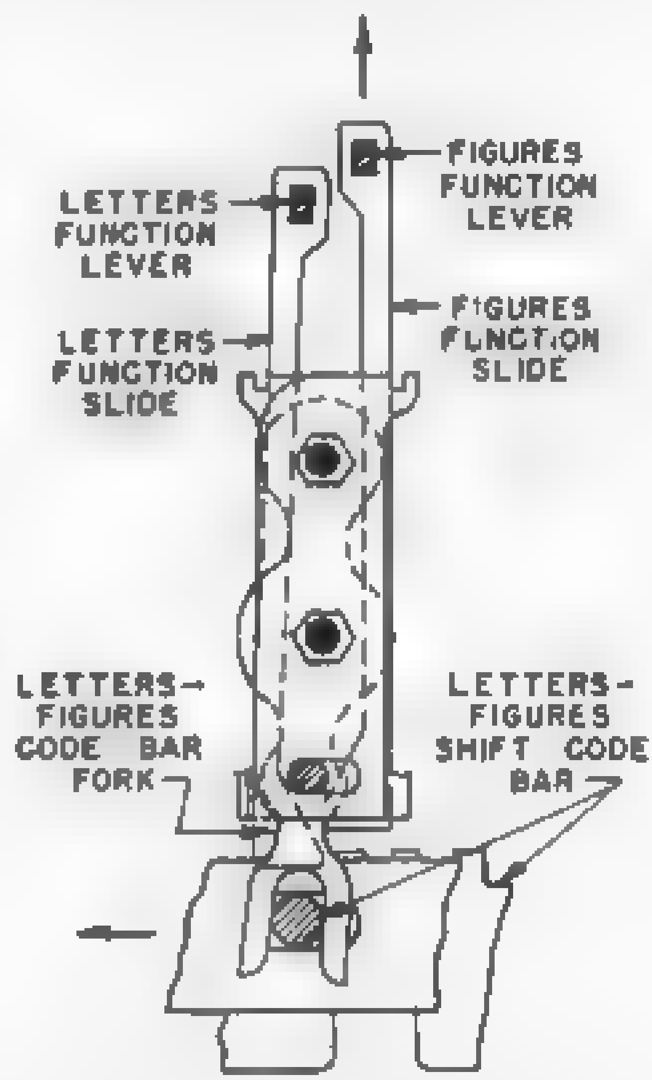

Figure 9. Letters-figures code bar shift mechanism in figures position

In this manner the stunt box can be equipped to react to a sequence consisting of any number of characters, limited only by the available slots in the stunt box.

reperforator cut in so it can follow line signals, it will be necessary to keep the contacts on the switch mechanism operated. This is accomplished by latching

up the function lever in the same manner as described under sequential selection, except in this case a release-type function

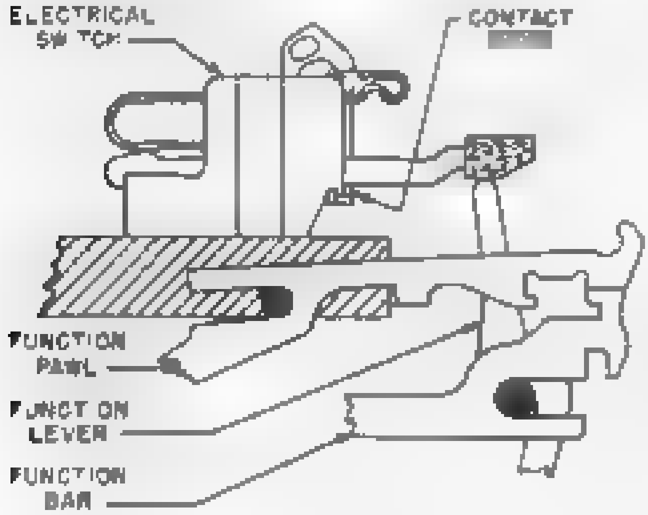

Figure 10. Switch mechanism unoperated

latch is used (Figure 14) which engages the latching type function lever when the lever is operated and stays latched up independent of the stripper blade. In order to disconnect the reperforator, a disconnect signal is used to activate two function bar mechanisms which are equipped with a release-type function lever (Figure 15). This function lever has a release projection which supports a latch-lever release shaft (Figure 16). Since the latch-lever release shaft has to span the release-type function lever latch, it is apparent that two release-type function levers are required to support each end of the latch-lever release shaft. The function bars associated with both release-type function levers are coded identically for the same disconnect character. As the disconnect code is received the two release-type function levers are activated, and the latch-lever release shaft engages the release-type function latch, releasing the function lever that was keeping the contacts on the switch mechanism activated as shown by Figure 14.

Way-Station Selector Operation

As mentioned before, the position of the code bars transmits to the type box positioning mechanism the information as to what character is to be printed. The type box positioning mechanism, however, is not allowed to operate until after the code combination which was read by the selector mechanism has been set up on the code

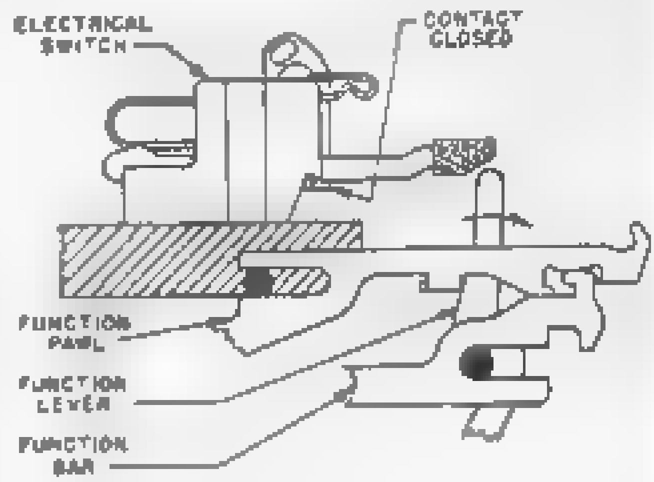

Figure 11. Switch mechanism operated

bars. After the code bars have been positioned, the type box clutch (Figure 17) is released, the type box positioning mechanism is allowed to function, and

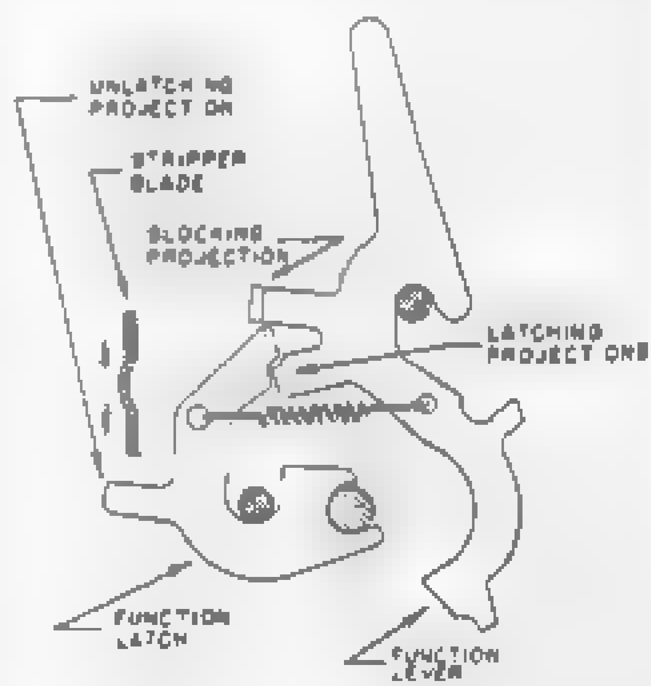

Figure 12. Function lever latched for duration of one character

subsequently the printing hammer is allowed to strike the proper type pallet in order to print the character. Therefore, if the type box clutch is prevented from releasing, printing will be suppressed even though the selector mechanism and the

code bars continue their operation when line signals are received. This is accomplished by the use of the suppression code bar.

In Figure 17 it can be seen that the end of the suppression code bar extends out from the left-hand side of the teleprinter and engages the blocking bail arm. When the blocking bail extension is in the path of the suppression arm, which is attached to the type box clutch trip arm, the type box clutch will not be tripped. When the blocking bail extension is removed from the path of the suppression arm, the type box clutch can be tripped so that printing can occur.

The suppression code bar is spring biased to the marking position, and in this position it holds the blocking bail extension in the path of the suppression arm. This condition of the teleprinter when printing cannot occur is called the "stunt case." When the teleprinter is in the stunt case, the only typing unit function that can operate is the carriage return. By moving the suppression code bar to the spacing position the blocking bail extension is removed from the path of the suppression arm. This condition of the teleprinter, which permits normal operation of the typing unit, is called the "print case."

The suppression code bar can be shifted to the spacing position with a code bar shift mechanism in the same manner that the letters-figures code bar is shifted. Since the suppression code bar is spring biased it is necessary to keep the function lever, which is operating the code bar shift mechanism, latched up with a release-type function latch. The teleprinter, therefore, can be shifted into "print case" by means of a function bar mechanism coded for a particular character or for a sequence of characters. The function lever, which locks the code bar shift mechanism in its operated position, can be released in the manner described under remote control, and the spring bias on the suppression code bar will then return the code bar to the marking position. The teleprinter in this manner can be returned to the "stunt case" by means of function bar mechanisms coded for a disconnect character or for a sequence of characters.

A three-station way circuit, for example, can be assigned the call letters of "A", "B", and "C", respectively. The function bars of the function bar assembly that is used for shifting the suppression code bar will be coded for "A" at the first station, "B" at the second station, and "C" at the third station. The disconnect can be an upper case F, and two function bar

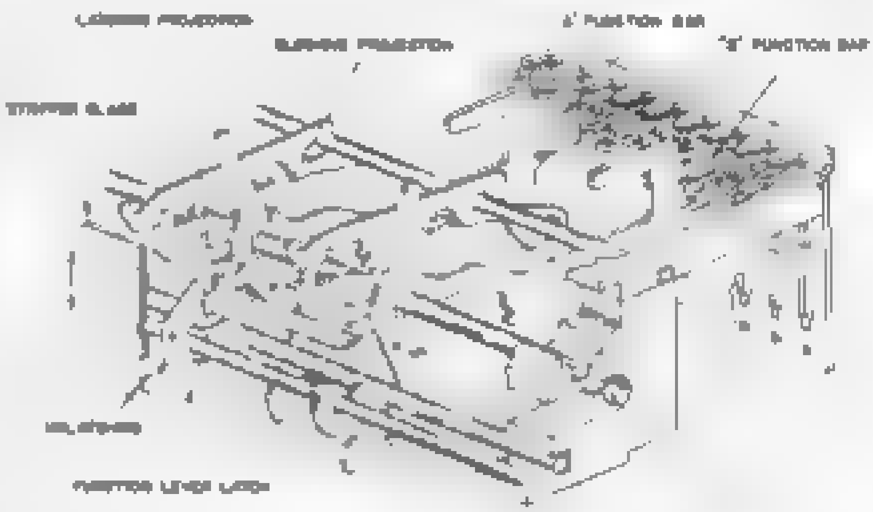

Figure 13. Sequential selection

mechanisms coded for this character will be used at all three stations. When station "A" calls station "B", the two call letter characters are transmitted and the two stations are shifted to the print case. It is almost certain, however, that the letter "C" will occur during the message being transmitted from "A" to "B"; therefore, some means is required to distinguish between the letter "C" when it is used as a call letter, or when it is part of a message. The zero code bar is used to accomplish this function. The zero code bar is also spring biased to the marking position. A cutoff character such as a "space" can be used to activate a function bar mechanism to shift the zero code bar to spacing by means of a code bar shift mechanism. The function lever associated with the zero code bar shift mechanism is latched up to

a release-type function latch to keep the zero code bar in the spacing position until the disconnect function is activated.

The condition of the teleprinter when the zero code bar is in the marking position is known as the "select case." When the zero code bar is shifted to spacing the teleprinter is in the "nonselect case." The call letter function bars can be coded with an additional marking time opposite the zero code bar. These function bars, known as select-type function bars, will be selected when the teleprinter is in the select case, but will be blocked when the teleprinter is in the nonselect case.

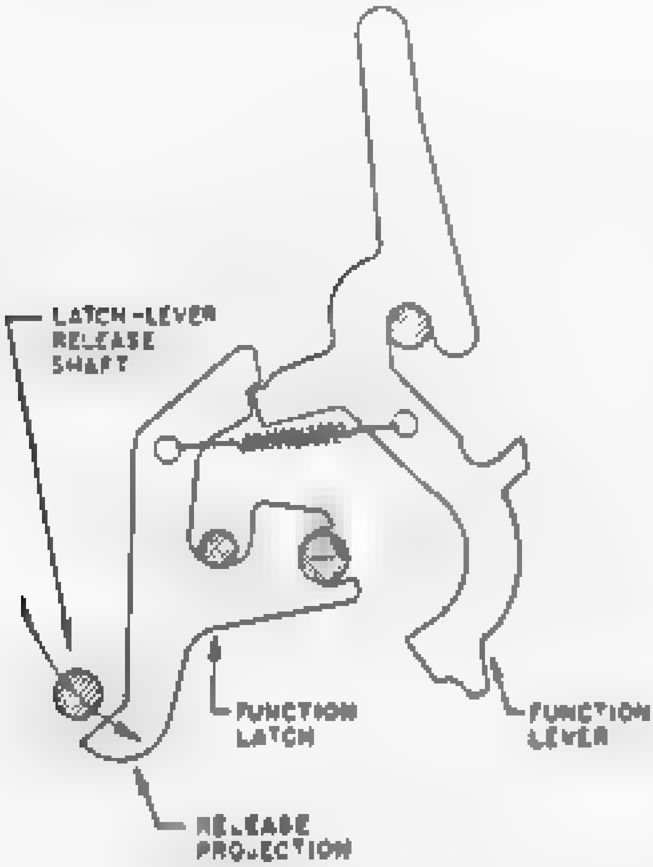

Figure 14. Function lever latched with release-type function latch

An additional function bar mechanism is added to the stunt box of all teleprinters in the way circuit coded for "space." Then, after the first station transmits the call letters "AB" followed by the cutoff character "space," the A and B stations are in the print case and nonselect case, and the C station is in the stunt case and nonselect case. Upon receiving the disconnect code all teleprinters are returned to the stunt case and also to the select case.

In case it is desired to control the sending of the uncalled stations, by means of switch mechanisms activated by the call and cutoff characters, the keyboard contacts of the uncalled stations can be shorted out. The disconnect signal would restore the keyboards by unlatching the function bar mechanisms that were operating the switches. In the same manner call lamps and busy lamps can be incorporated if desired.

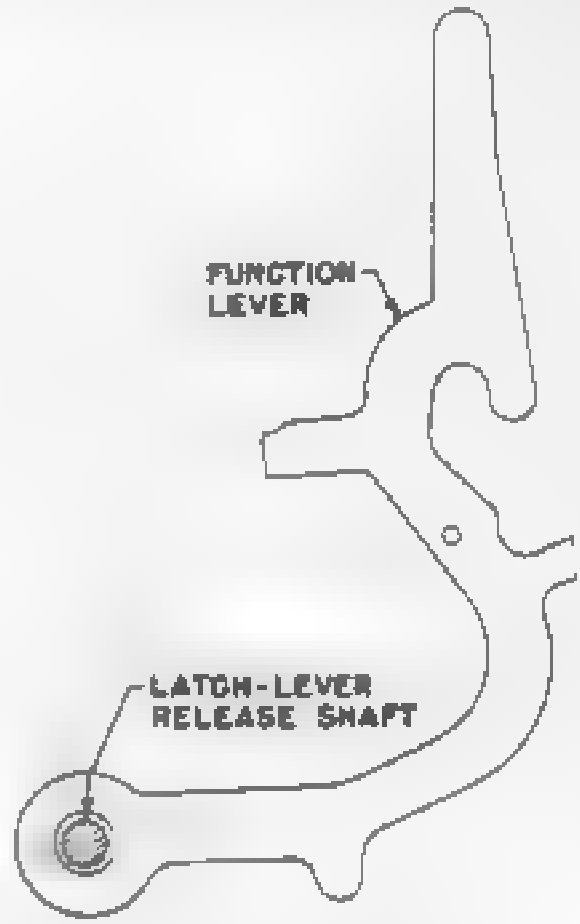

Figure 15. Release-type function lever

Integrated Data Processing

The Model 28 teleprinter lends itself readily to the processing of data that are normally cumbersome to handle by ordinary means. This can be attributed not only to the many functions that can be accomplished in the stunt box of the teleprinter, but also to additional features such as automatic page feed-out (form indexing), horizontal tabulation, sprocket feed, and higher operating speeds that are available with the Model 28 teleprinter

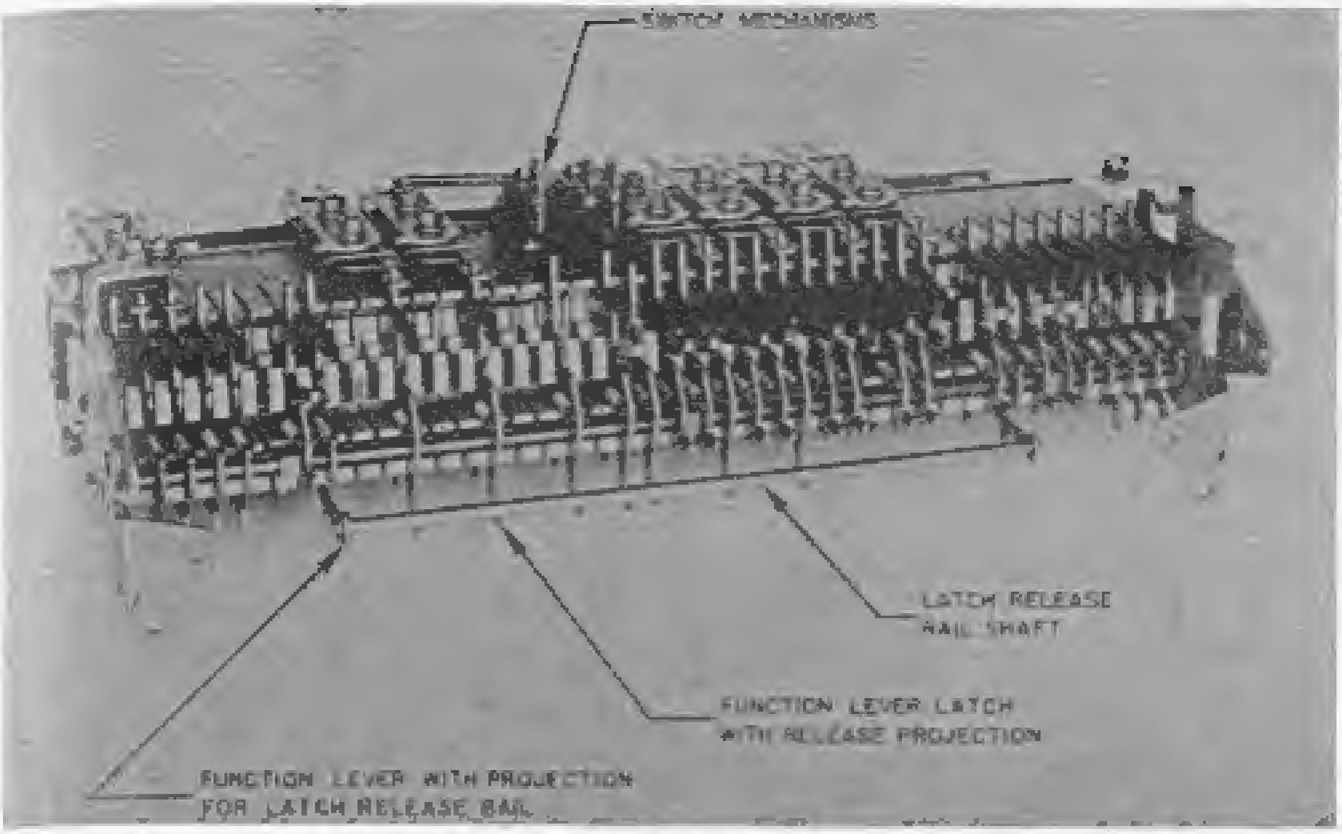

Figure 16. Bail mechanism

Automatic page feed-out is activated by a function bar mechanism in the stunt box that responds to a particular character. When the mechanism is activated the paper is fed out to a predetermined position. This is very helpful in cases where preprinted forms are used in the teleprinter and automatic form indexing is desired.

The stunt box can be equipped with previously described mechanisms to control transmitters, reperforators or other teleprinters. The data to be transmitted to the various departments of a concern in certain operations usually contain a great deal of constant material. This material can be stored in a master tape. When the master tape is placed in a transmitter, the Model 28 teleprinter stunt box can be used to stop and start the transmitter for manual insertion of variable data and/or insertion of data by another transmitter. The stunt box will also edit the information being transmitted by means of cutting in and out several reperforators with switching characters in order to select only the desired

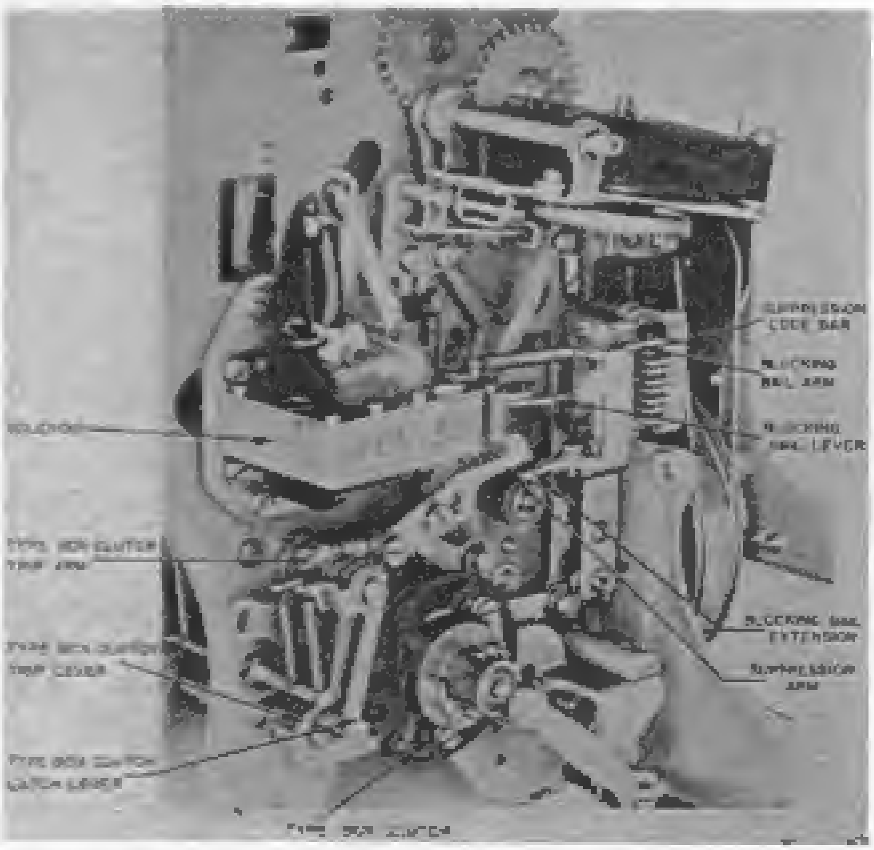

Figure 17. Model 28 teleprinter stunt case shift mechanism

information that is to be retransmitted to the various destinations.

One of the outstanding features of the Model 28 teleprinter stunt box in this type of operation is the ability to suppress printing and spacing on a large number of characters which are used for switching. Referring back to Figure 6, it can be seen that an extension can be added to the lower part of the function lever to engage the space suppression bail which extends across the entire width of the teleprinter. When this function lever is activated by the character for which the function bar mechanism is coded, spacing will be suppressed for that character. In addition individual upper-case or lower-case type pallets in the type box can be easily replaced with blank pallets for characters which are not to be printed. In this manner any combination of printing or nonprinting and spacing or nonspacing can be obtained for a large number of switching characters.

Conclusion

The individual types of function mechanisms that are available in the stunt box are relatively few and simple. However, the use of these mechanisms in combination with each other, and the capacity of the stunt box for a large number of function mechanisms makes the Model 28 teleprinter a highly versatile unit.

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E. Louis Parkington graduated from the University of Texas in February 1948, having previously studied at New York University; during World War II he was in charge of an UHF radio terminal in the Signal Corps. He joined the Telegraph Company in 1948 as Field Engineer at Dallas, was assigned to testing Plan 21 Reperforator Switching installations and then transferred to the Kansas City Area office where he has been concerned mainly with circuit layout, and testing of carrier, repeater, and private wire equipment. Recently, he has been on detail in New York where he worked in the Patron System Engineer's office on Switching System 56-A and developed methods of way-station selection and remote control using the Model 28 Teleprinter. Mr. Parkington is an Associate Member of AIEE and a member of the Armed Forces Communications and Electronics Association in which he has held the office of Secretary-Treasurer; he is presently a member of the Board of Directors of the Kansas City Chapter of the AFCEA.

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Electrosensitive Recording and Duplicating Blank

D. P. Robbin, B. L. Kline

2,726,168—December 6, 1955

A facsimile recording blank adapted for duplicating received messages by the hectographic process which comprises a base layer of conductive paper, a first coating comprising a water-soluble dye such as methyl violet in a nonwater-soluble binder, and a top conductive coating utilizing a binder in a volatile nonaqueous solvent. The carbon content of the latter coating is such as to permit removal of the coating by recording stylus current of proper value so as to expose but not otherwise disturb the dye layer.

Polar Relay

W. D. Buckingham

2,732,454—January 24, 1956

In a polar relay of the type described in Patent No. 2,732,458 below, the relay casing is composed of laminations which serve as the return path for the operating flux,—hence improving both operating efficiency and winding space factor. To limit wear, rolling of the ball armature is promoted by choosing material of relatively small magnetic retentivity and then increasing surface hardness as by case hardening or plating with tungsten carbide or molybdenum. Bias is adjusted by orientation of an auxiliary permanent magnet.

Cross-Talk Suppression

J. E. Boughtwood

2,732,431—January 24, 1956

The interchannel cross-talk caused by the overlapping of received pulses in a pulse modulation receiver is corrected by a 3-step procedure. Overlapping by the leading edge of the wave is corrected by a phase shifting network, by the trailing edge by a differentiating network, both corrections being made in the common receiving amplifier, while "long term" cross-talk which spreads out over several pulses is corrected by a coupling circuit common to all channel detector-amplifiers.

Facsimile Transmission System and Apparatus

G. H. Ridings, J. H. Hackenberg, R. J. Wise, G. B. Worthen, D. M. Zabriskie

2,732,276—January 24, 1956

A conductive pickup facsimile transceiver in which a balanced stylus mount is enclosed in a protective housing which automatically tilts upward when returned manually to starting position, at the same time causing the stylus to retract into the housing. Upon starting, the stylus and housing both drop automatically into scanning position. The carriage is drawn along the length of the drum by a cord which wraps around a reel driven by a synchronous motor until an end-of-message contact is reached and the machine automatically stops. Various other safety features as well as circuitry and operating procedures are described.

Polar Relay

W. D. Buckingham

2,732,458—January 24, 1956

A polar relay embodying a contact assembly of one movable and three fixed elements all enclosed in an evacuated glass tube about 1/4 inch in diameter insertable into a cylindrical space between the relay pole pieces. The magnetic armature is composed of a sintered combination of iron, tungsten carbide and other materials designed to impart hardness and good conductivity and is preferably in ball form arranged to roll on one contact element while oscillating between the other two. Bias is controlled by shifting the location of the permanent magnet. Various alternative assemblies are shown.